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PRESSURE TUBE ELONGATION RATE STUDY FOR PNGS-A UNITS 3 AND 4

Report No 84-289-K

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ABSTRACT

The methods and procedures of updating the fast neutron flux profiles were modified to increase their efficiency and reduce the chance of error. They were then used to update the files and examine the relationship between pressure tube elongation and fast neutron flux for PNGS-A units 3 and 4. The current growth rate was found to be in the neighbourhood of 0.101 to 0.105 mm/GWH (3.27 to 3.30 mm/7000 EFPH). Statistical tests could not detect any significant acceleration effects or zonal differences.

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To Mr. B. Montford
Manager - Chemistry & Metallurgy
Central Nuclear Services

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D.C. Goushleff

1. INTRODUCTION

The Operations Research Department has performed a study of Pressure Tube elongation rates at PNGS-A at the request of the Fuel Channel Materials Section of Central Nuclear Services.

The study was composed of two parts. The first consisted of updating the fast neutron flux files maintained by the Section using the SORO flux maps generated by the Fuel and Physics Department.

In the second part of the study, the elongation rates of the pressure tubes in PNGS-A units 3 and 4 were examined for significant differences between the units and for variations in rate between the measurement intervals.

The four most recent elongation measurements on P3 and P4/1,2/ were used for this study because of the high reliability of the STEM-spot-face measurement technique used. Fuel channels that had been replaced since startup were excluded from the study. Refer to Table 1 for the measurement dates.

2.0 METHODOLOGY

The modifications to the Fast Flux programs utilized the fact that the data blocks of the SORO masterfiles are generated in a unique sequence depending on whether a FLUX, BURN, or SHIFT has occurred. When an algorithm was written to do this, the tiresome task of personally determining the correct states and preparing the data cards in the correct syntactical order to run the integration program was eliminated.

The integrated channel powers were then converted to fluence and transferred from the UNIVAC to the IBM computer in E14.9 card image format to preserve precision and eliminate the error-prone method of manually key-punching a fluence map from microfiche.

The data was then analyzed and plotted using package statistical programs first in APL and then SAS/6,7/.

Two methods of computing elongation rates were defined: the Bulk rate, which is obtained by linear regression of elongation vs fluence, and the Individual rate, which is obtained by dividing the difference in elongation for any two consecutive measurements by the corresponding change in fluence for each channel.

Thus, the Bulk rates indicate the average growth rate of the pressure tubes since startup and the Individual rates provide "instantaneous" or current trends. According to the Constant Rate Elongation Model (CREM) theory/3,4,5/ channel elongation is a linear function of fluence and both rates should agree, either on a zone or entire core basis. A disagreement between them could be due to measurement error (either in elongation or fluence), or inadequacies in the current theory.

Comparisons were made between units, reactor power zones, and measurements. Regressions were made on the Bulk data and compared using dummy analysis techniques; regressions were also made on the Individual rates for evidence of acceleration, and comparisons of mean rates were made using Duncan's Means Test/6,7/.

3.0 RESULTS

3.1 Units and Measurements

The references cited in this report do not use a common set of units when correlations are made between channel elongation and fluence. Typical fluence units used are GWH, 7000 EFPH, 4648 x 10^{17} N/Cm^2, and 10^{18} N/Cm^2.

All regressions in this report use channel GWH as the regressor, which is defined as the total fission energy generated by a fuel channel at the point in time when the elongation measurement was taken. They are taken from the monthly integrated bundle and channel power files maintained by CNS.

The equations used for conversion between the different units are shown in Appendix 2.

It should be mentioned that EFPH cannot be used as a regressor, but is only a rule of thumb used to estimate the length of zone 5 channels, which have an energy clock approximately 15 - 20% greater than the average channel.

3.2 Updating the Fast Flux Files

The Fast Flux data files were updated to the end of December 1983 for all units at BNGS-A and PNGS-A.

Univac Symbolic Stream Generator was used to generate runstreams that unload the SORO tapes and run the Fast Flux programs. This expedites the entire updating process. Copies can be found in Appendix 1, along with instructions.

Furthermore, checks were added to the integration program that match the fluence with the reactor energy: a significant difference would indicate that a computational error has occurred.

When such an error was detected, reruns were made on any affected unit to a point in time prior to the first STEM-spotface measurement in order to obtain a consistent set of fluence maps across all measurements. The microfiched fluence maps maintained by the Section data clerk were then replaced.

3.3 Trends in Elongation Rates

3.3.1 Comparison of Bulk Elongation Rates

Table 1 summarizes the Bulk elongation rates for both units and all measurements in mm/GWH and mm/7000 Equivalent Full Power Hours (7000 EFPH).

Although there are apparent differences in the regression rates found for all measurements on all units, there are some significant similarities: five of the measurements (P3-1980, P3-1982, P3-1984, P4-1980, P4-1984) have a common dummy regression slope, and the variation in the measurments can be attributable to statistically in significant shifts in the intercept (ie the model is asked "If these measurements have a common slope, is it significant and is there any difference between the intercepts?").

When complete freedom is given to the model (ie "Are the individually obtained slope and intercepts in agreement?") only 4 of the measurements agree (P3-1980 P3-1982, P3-1984, P4-1980), with additional agreement between (P4-1980 and P4-1984).

In the dummy regression technique, the P4-1984 data was used as a base case against which all the other measurements were compared. The Bulk elongation rate of these measurements varied between 0.101 and 0.105 mm/GWH (3.27-3.40 mm/7000 EFPH). Although a common regression rate could be derived by "stringing" the data from these four measurements together, this

is not an advisable procedure because of the nature of the systematic errors involved (which probably accounts for the variation in the intercepts, see Section 3.2.2 below). Figure 11 displays the regression rates versus average channel GWH for each measurement.

An examination of simplified plots of the measurements (Figures 1-2) clearly demonstrates the lack of fit of the 1977-78 measurements from both reactors. Figures 3 to 10 are the Bulk data plots of each measurement, using the same scaling to facilitate comparisons, Figures 14 and 15 plot all measurements on one graph for each unit.

Another set of dummy regressions indicates that generally there is no significant difference in Bulk elongation rate by reactor power zones for each measurement. These tests are valid at the 5% level of significance.

Table 3 contains the zonal regression rates: the dummy regressions used zone 5 as the base case, and note that some of these rates appear to be quite high (4.38 mm/(7000 EFPH), particularly for P4. Although there is some visual indication that the regression rate increases with power zone in P4, this trend could not be corroborated statistically for either unit, or visually for P3. Figures 12 and 13 plot the Bulk regression rate versus average channel GWH for each power zone. There is some visual evidence of a decreasing trend in average bulk elongation rate for each unit.

3.3.2 Possibility of Measurement Errors

The P3 1982 measurement agrees in slope but is significantly higher than the 1984 measurement by 1.25 mm (as demonstrated by a visual comparison of Figures 5 and 6). Although a possibility exists that the error may be in the fluence rather than in the measurement, the magnitude (approximately three months of SORO runs) makes this unlikely.

There is statistical and visual evidence that the pre-1980 measurements on both units are in error.

It could be possible that small systematic errors are made in measuring the elongation rate that account for the variation of the intercept point of each regression which would make it difficult to "string" the measurements together; a single linear regression would be blind to this typed error though a hypothetical common growth rate exists. The best that can be said is that it lies somewhere between 0.101 and 0.105 mm/GWH, if the five measurements that agree with one another, are the true ones.

3.3.3 Evidence of Acceleration

A linear regression on the Individual rates provides an estimate of the second derivative of the elongation rate and a statistical test of its significance: if the CREM theory is valid, the growth rate should be constant and the slope of a linear regression on the Individual rates should be zero.

This analysis requires that two measurements be made on one reactor with no evidence of error, and the only incidence appears to be the P3 1980 and 1984 data.

No evidence of reqression was found (R-SQUARE = 0), and consequently there is no evidence of acceleration.

3.2.4 Individual Elongation Rates

The only reliable Individual elongation rate appears to be that computed for the P3 1980 and 1984 data and is .0948 mm/GWH (2.99 mm/7000 EFPH), which is about 7% below the common Bulk rate but the two numbers are not directly comparable: the Individual rate represents the growth rate of P3 tubes from 1980 to 1984 whereas the common Bulk rate can be considered to be the long-term average. As no regression could be performed on the Individual rates, this figure represents an arithmetic average of all channels.

No statistical difference could be found in the rate when the reactor power zones were compared with one another using Duncan's Means Test.

4.0 CONCLUSIONS

4.1 Five of the Eight measurements made on P3 and P4 have a common elongation growth rate which lies somewhere between 0.101 to 0.105 mm/GWH.

4.2 Systematic errors could account for vertical shifts of a hypothetical common regression line.

4.3 No statistically significant variation could be found in elongation growth rate by reactor power zone, although some visual evidence exists in P4.

4.4 No statistical evidence of acceleration could be found, but there is slight visual evidence of decelleration on both units.

4.5 The P3-1978 and P4-1977 regressions are clearly different from the other measurements and from each other.

Approved: Submitted:

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2. J.R. Lamarre, Filing Memorandum, August 2, 1984 (PNGS-A Unit 3 Elongation Measurements), File PGA (NA44)31110.023.

3. H.C. Jamieson et al., CNS-IR-18, September 1976; CNS-IR-311-21 and CNS-IR-311-23, April 1977.

4. A.H. Chung and A.L. Punhani, "Correlation of Pressure Tube Elongation with Fast Neutron Fluence and Operating Temperature in Pickering NGS-A, Units 3 and 4". Ontario Hydro Research Division Report No 78-412-K, October 12, 1978.

5. A.R. Causey, "P3 and P4 Pressure Tube Elongation Rates". AECL Memorandum to A.G. Norsworthy, February 10 1984.

6. "SAS User's Guide: Statistics", SAS Institute Inc. POB 8000 Cary, North Carolina, 1982.

7. R.J. Freund, R.C. Littell," SAS for Linear Models", SAS Institute Inc., POB 8000 Cary, North Carolina.

FIGURE 1

PNGS-A BULK ELONGATION DATA
AVERAGED WITHIN 10 GWH BAND WIDTHS
UNIT=3

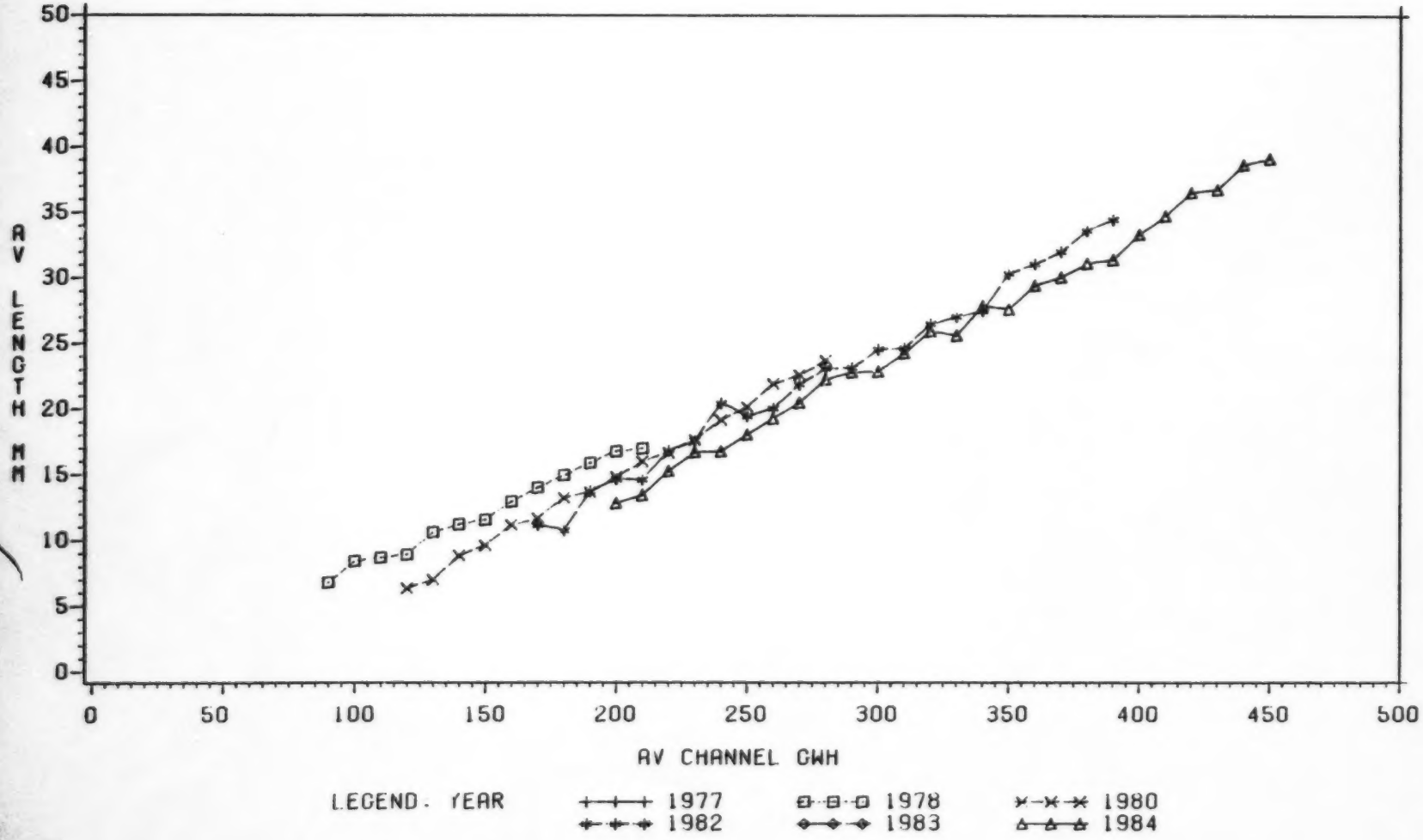

FIGURE 2

PNGS-A BULK ELONGATION DATA
AVERAGED WITHIN 10 GWH BAND WIDTHS
UNIT=4

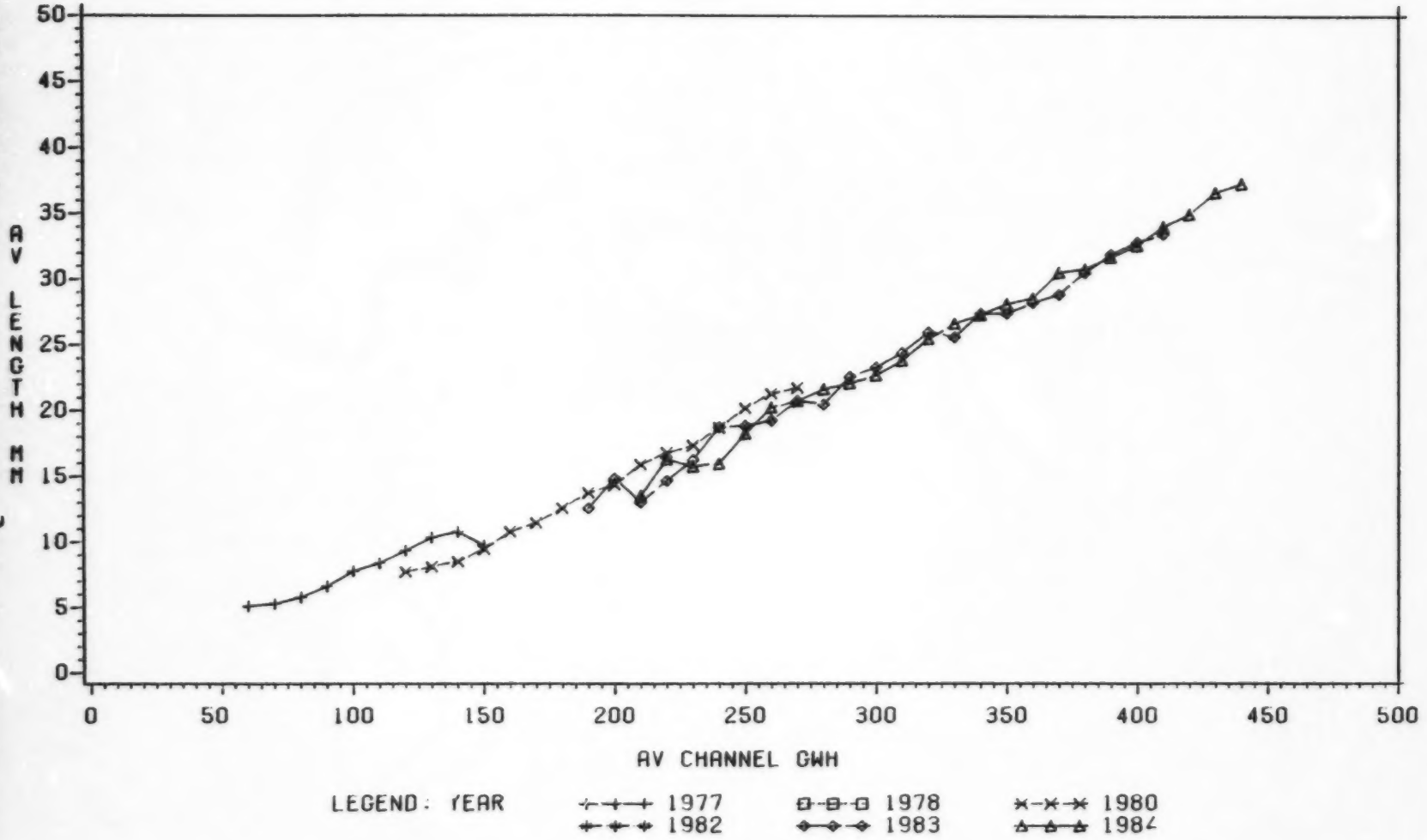

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FIGURE 3
PNGS-A BULK ELONGATION DATA
WITH LEAST SQUARES REGRESSION LINE
UNIT=3 YEAR=1978

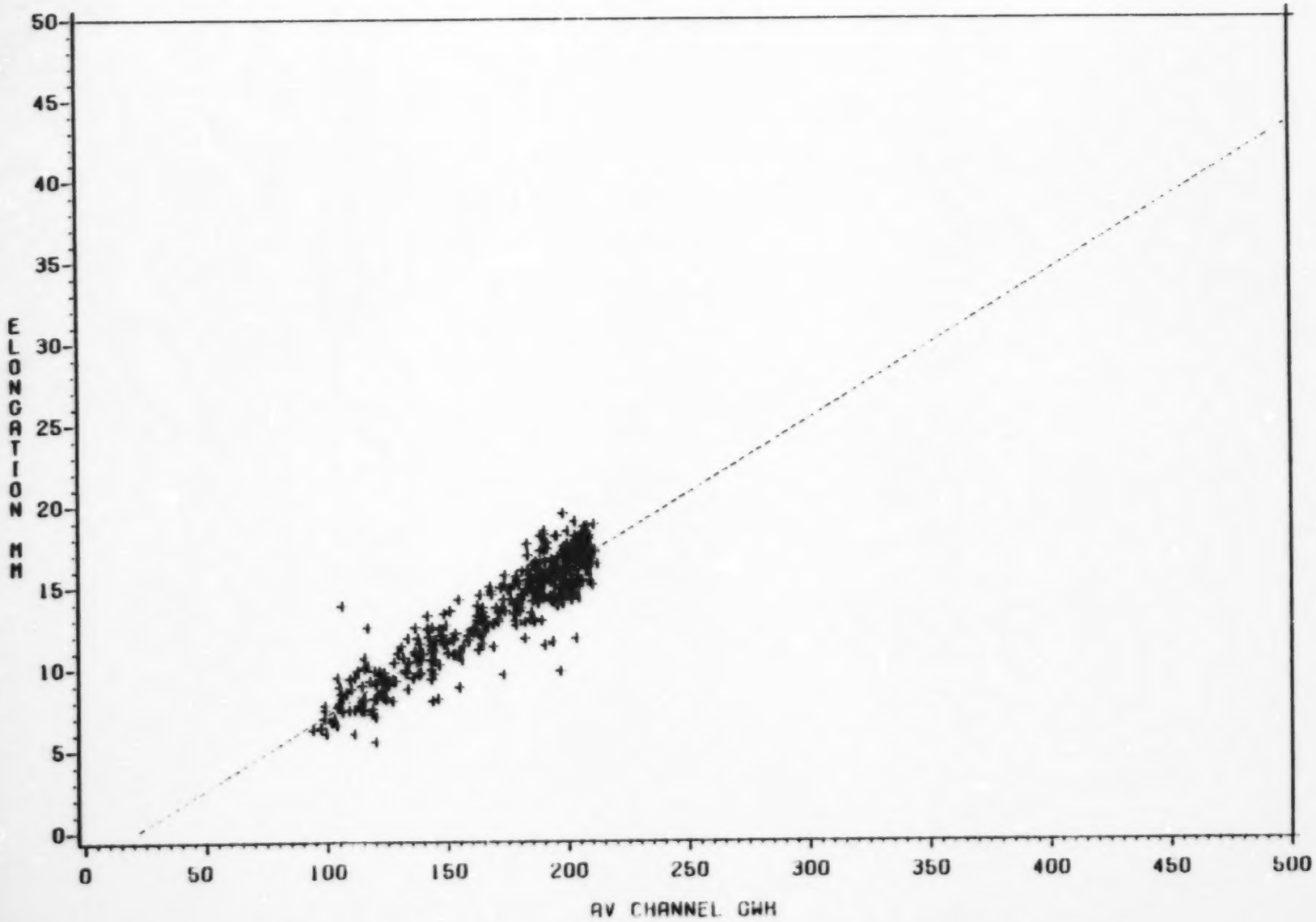

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FIGURE 4
PNGS-A BULK ELONGATION DATA
WITH LEAST SQUARES REGRESSION LINE
UNIT=3 YEAR=1980

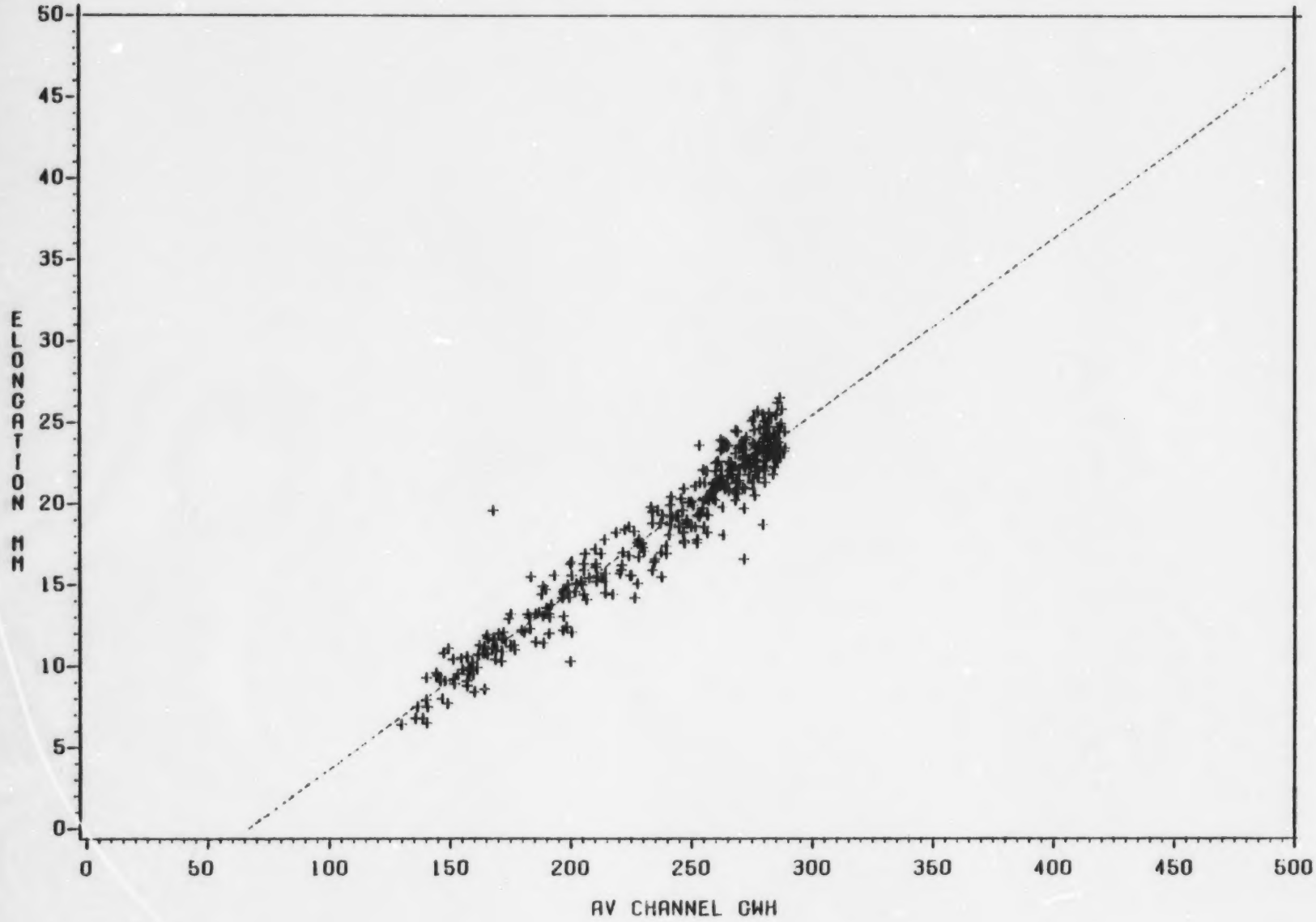

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FIGURE 5
PNGS-A BULK ELONGATION DATA
WITH LEAST SQUARES REGRESSION LINE
UNIT: 3 YEAR: 1982

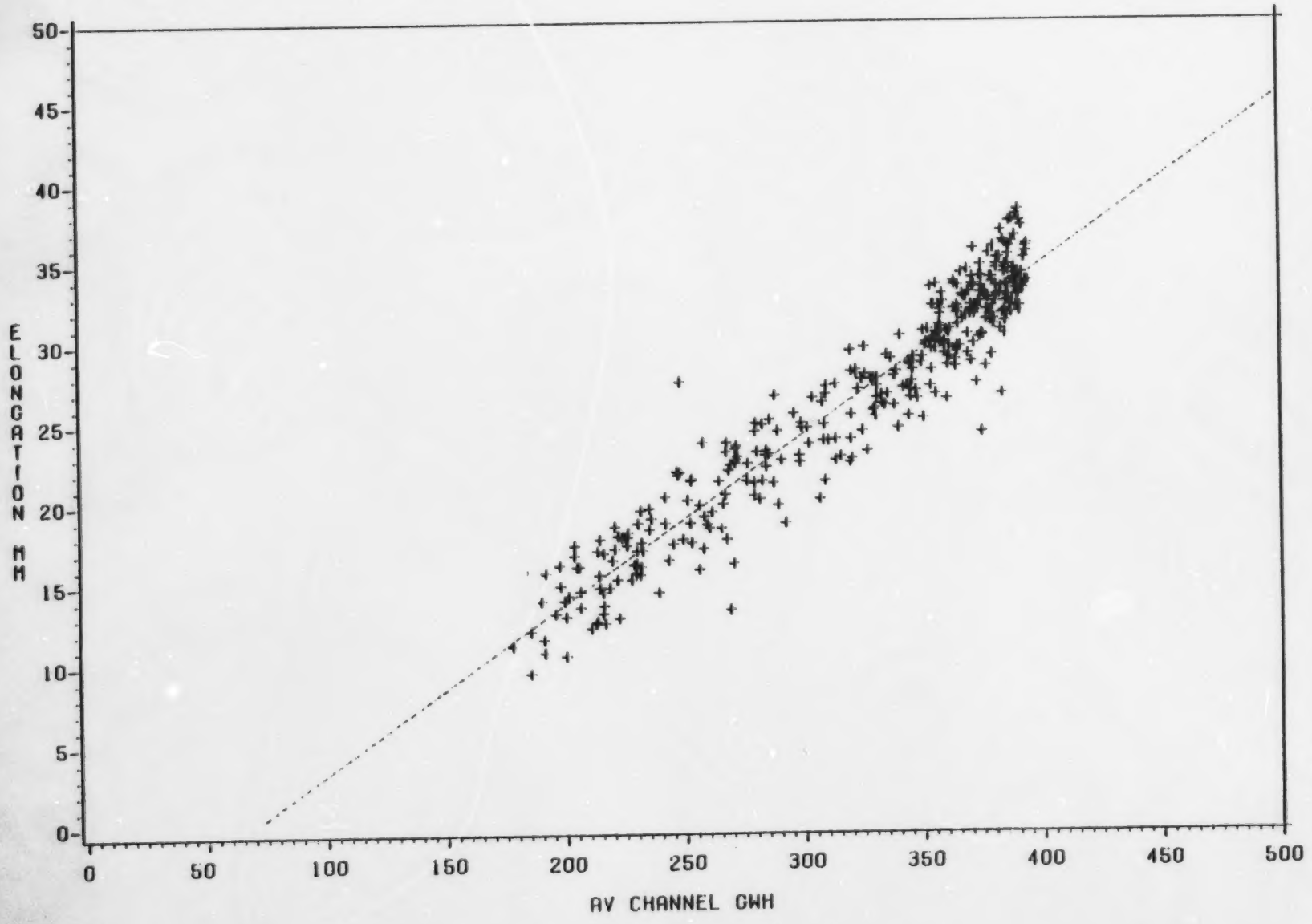

FIGURE 6
PNGS-A BULK ELONGATION DATA
WITH LEAST SQUARES REGRESSION LINE
UNIT=3 YEAR=1984

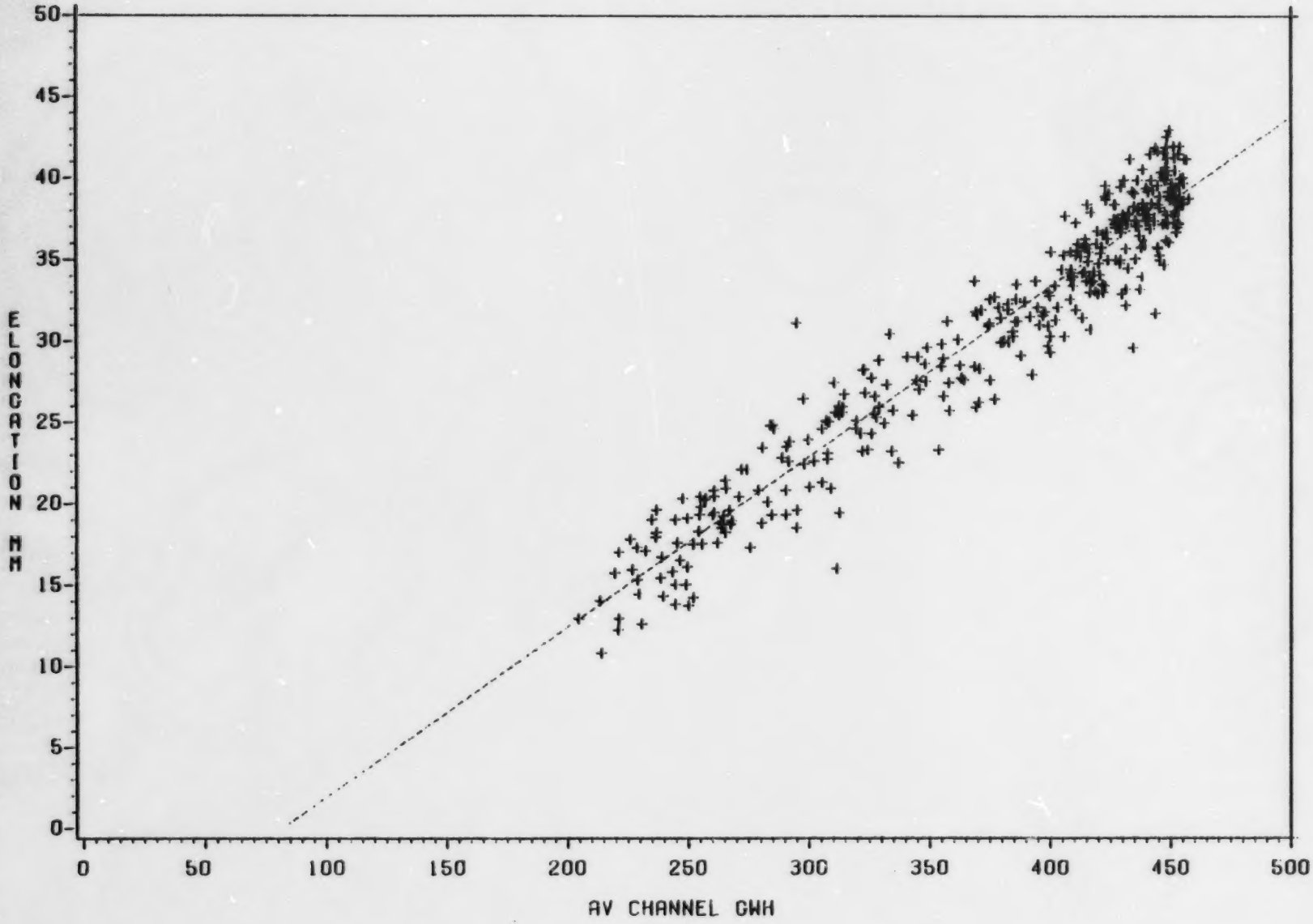

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FIGURE 7
PNGS-A BULK ELONGATION DATA
WITH LEAST SQUARES REGRESSION LINE
UNIT=4 YEAR=1977

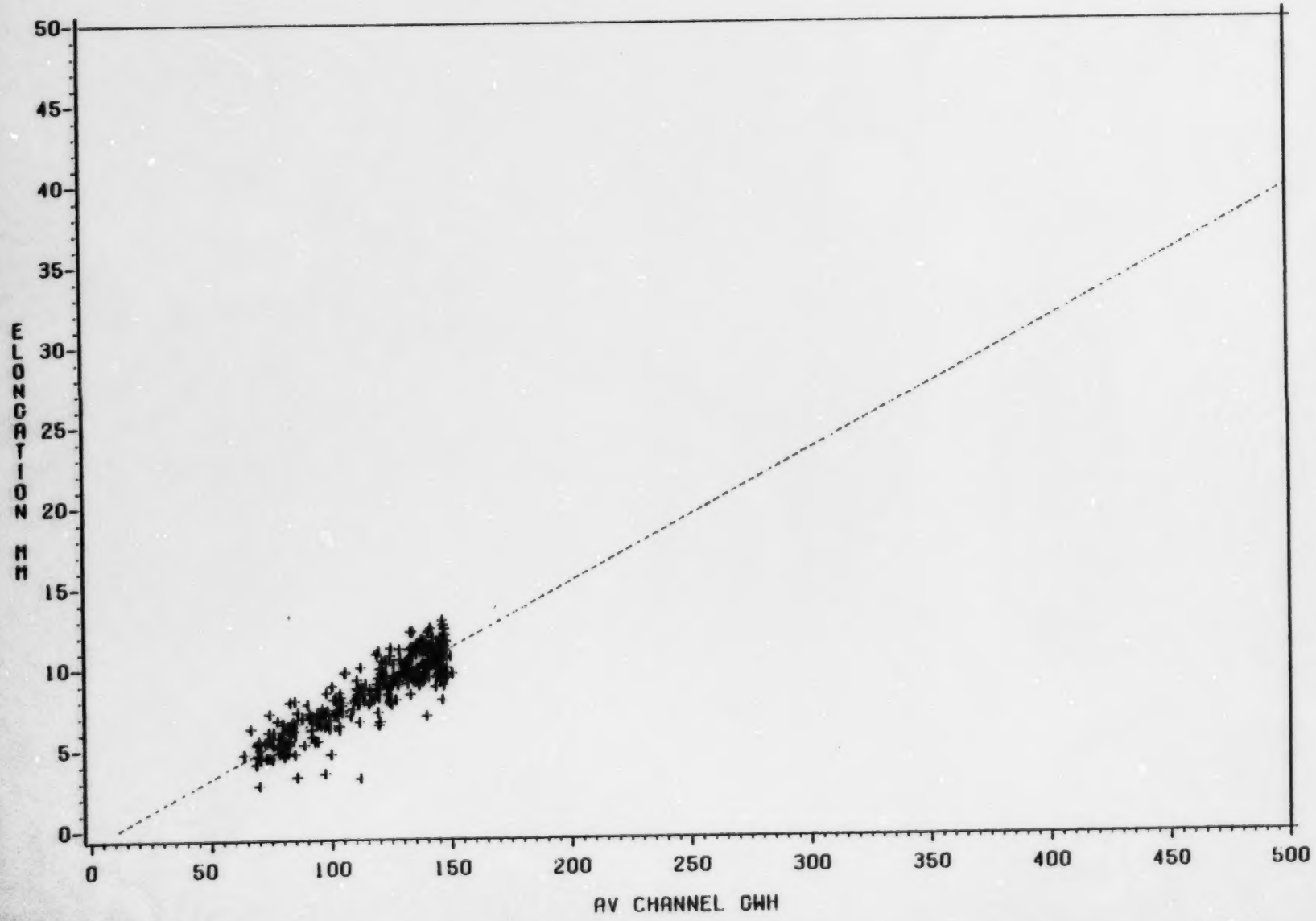

FIGURE 8
PNGS-A BULK ELONGATION DATA
WITH LEAST SQUARES REGRESSION LINE
UNIT=4 YEAR=1980

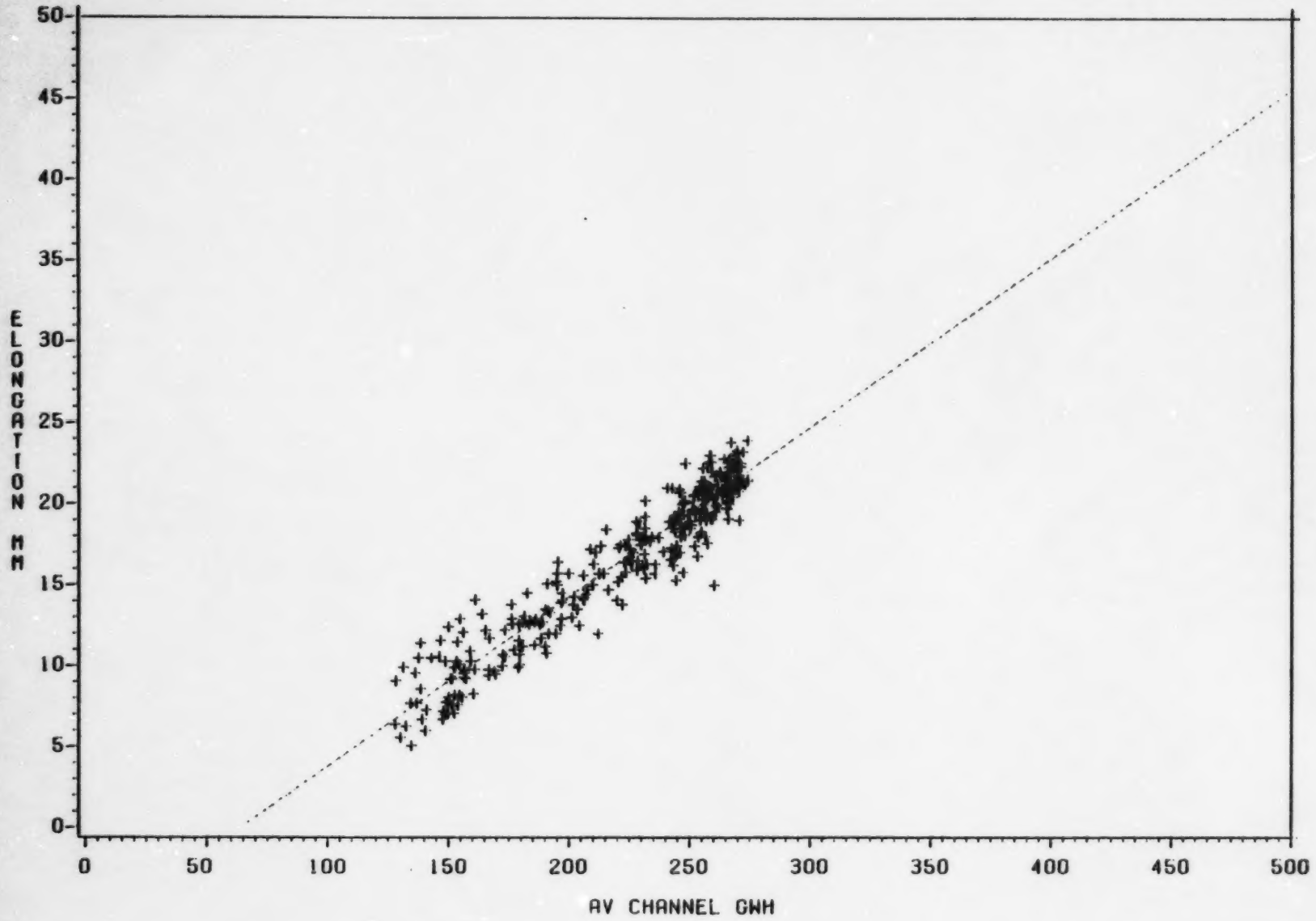

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FIGURE 9
PNGS-A BULK ELONGATION DATA
WITH LEAST SQUARES REGRESSION LINE
UNIT=4 YEAR=1983

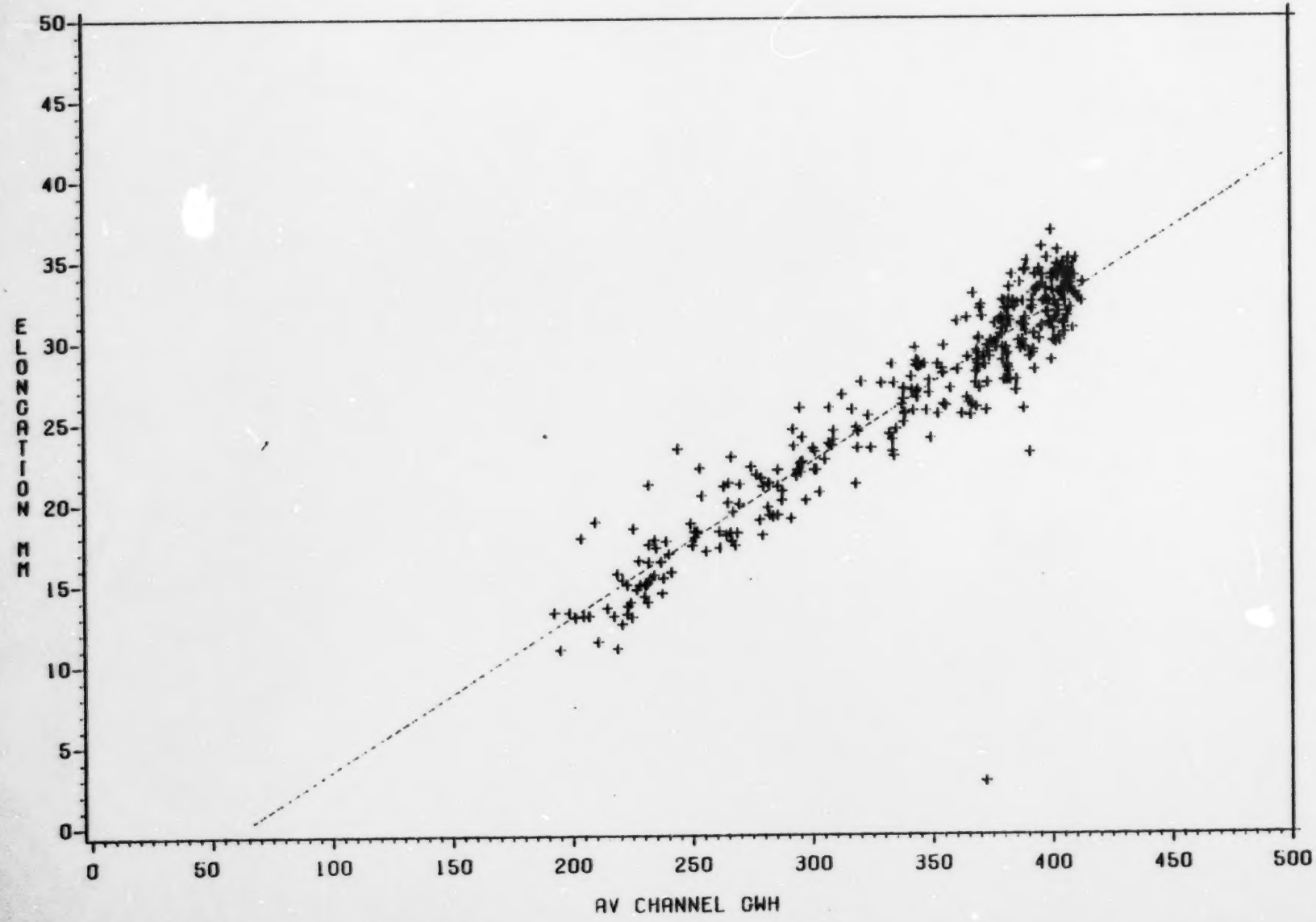

FIGURE 10
PNGS-A BULK ELONGATION DATA
WITH LEAST SQUARES REGRESSION LINE
UNIT=4 YEAR=1984

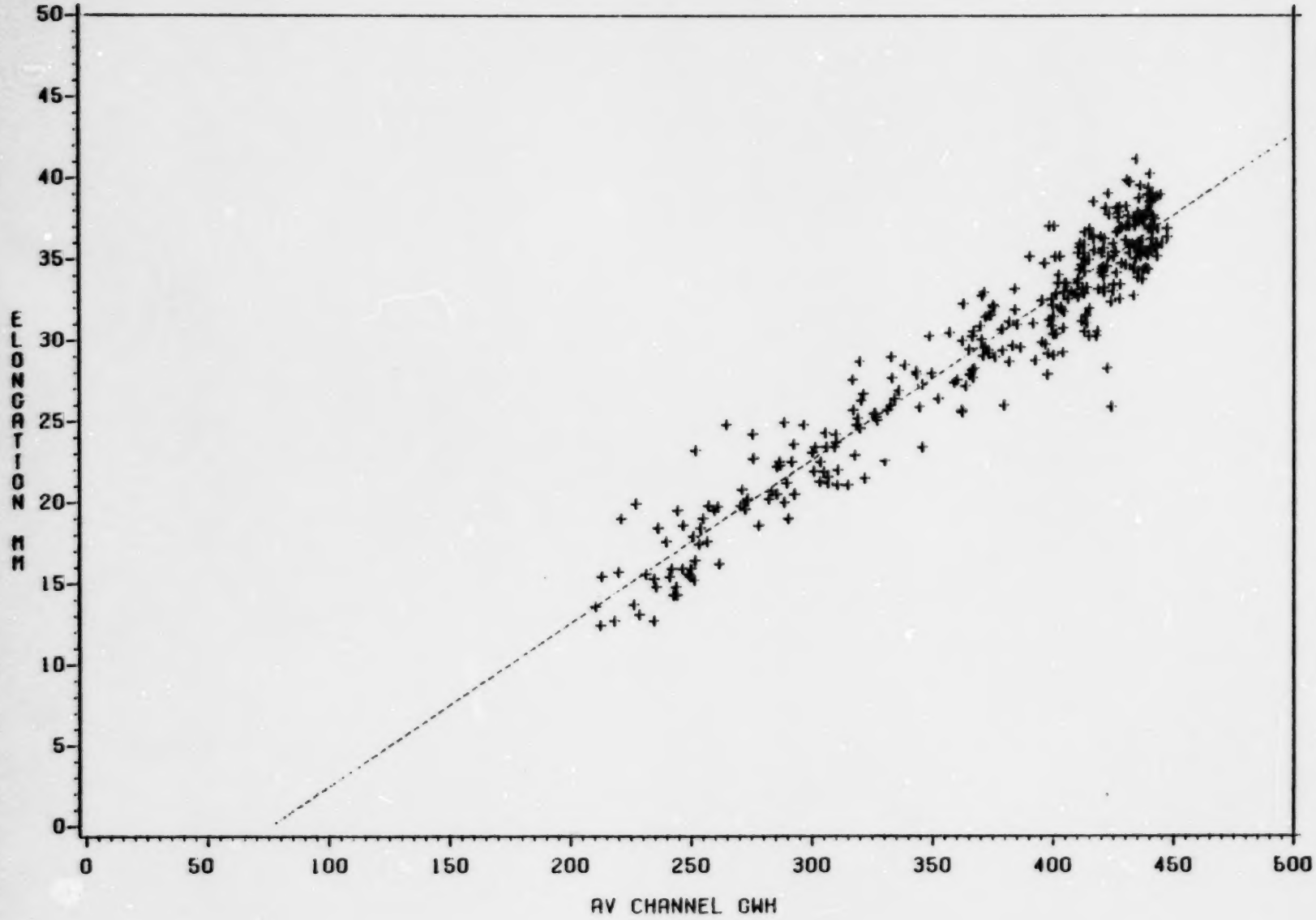

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FIGURE 11

PNGS–A BULK ELONGATION DATA
AVERAGE REGRESSION RATES
ALL MEASUREMENTS

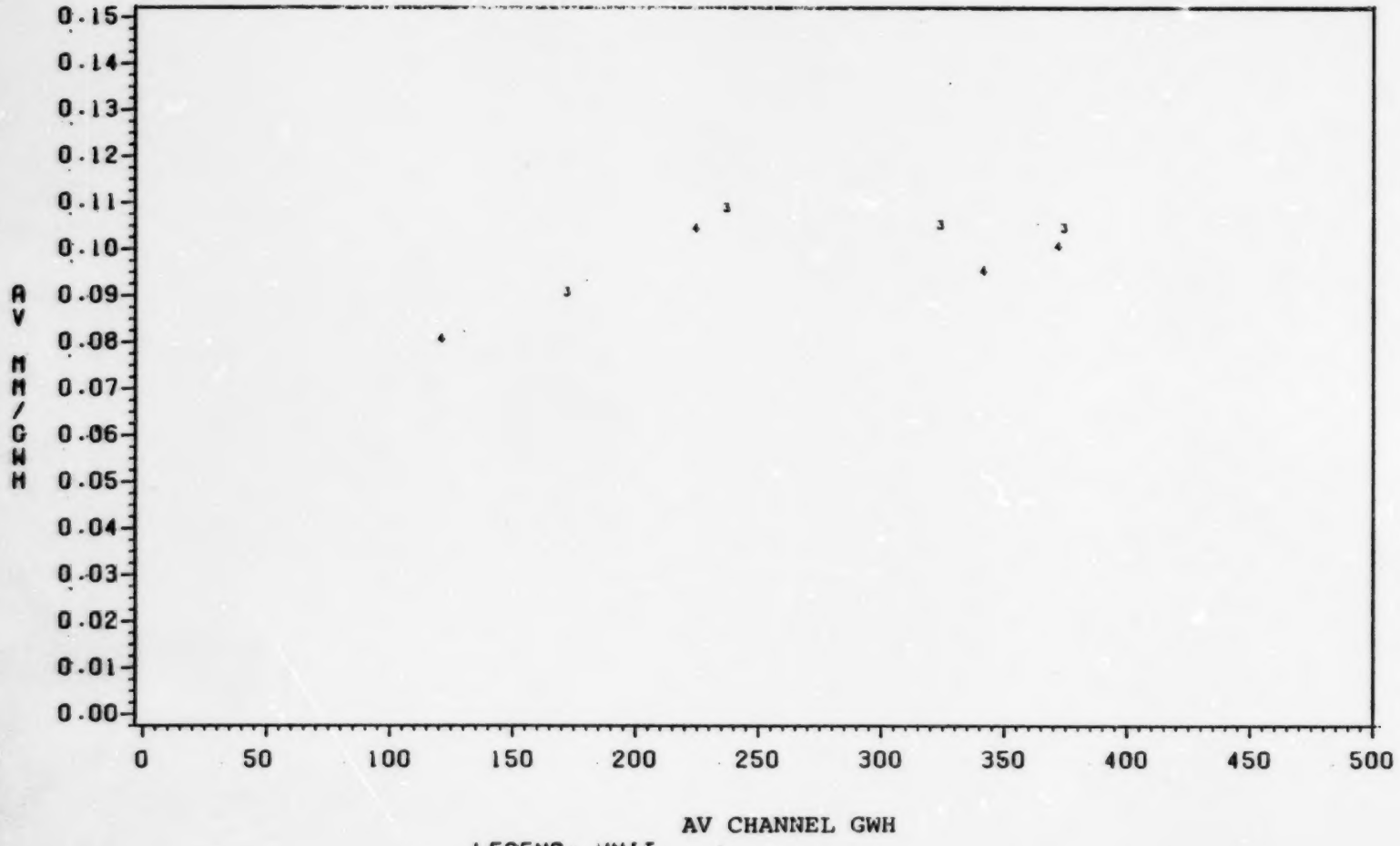

FIGURE 12

PNGS-A BULK ELONGATION DATA
AVERAGE REGRESSION RATES
BY ZONES
UNIT=3

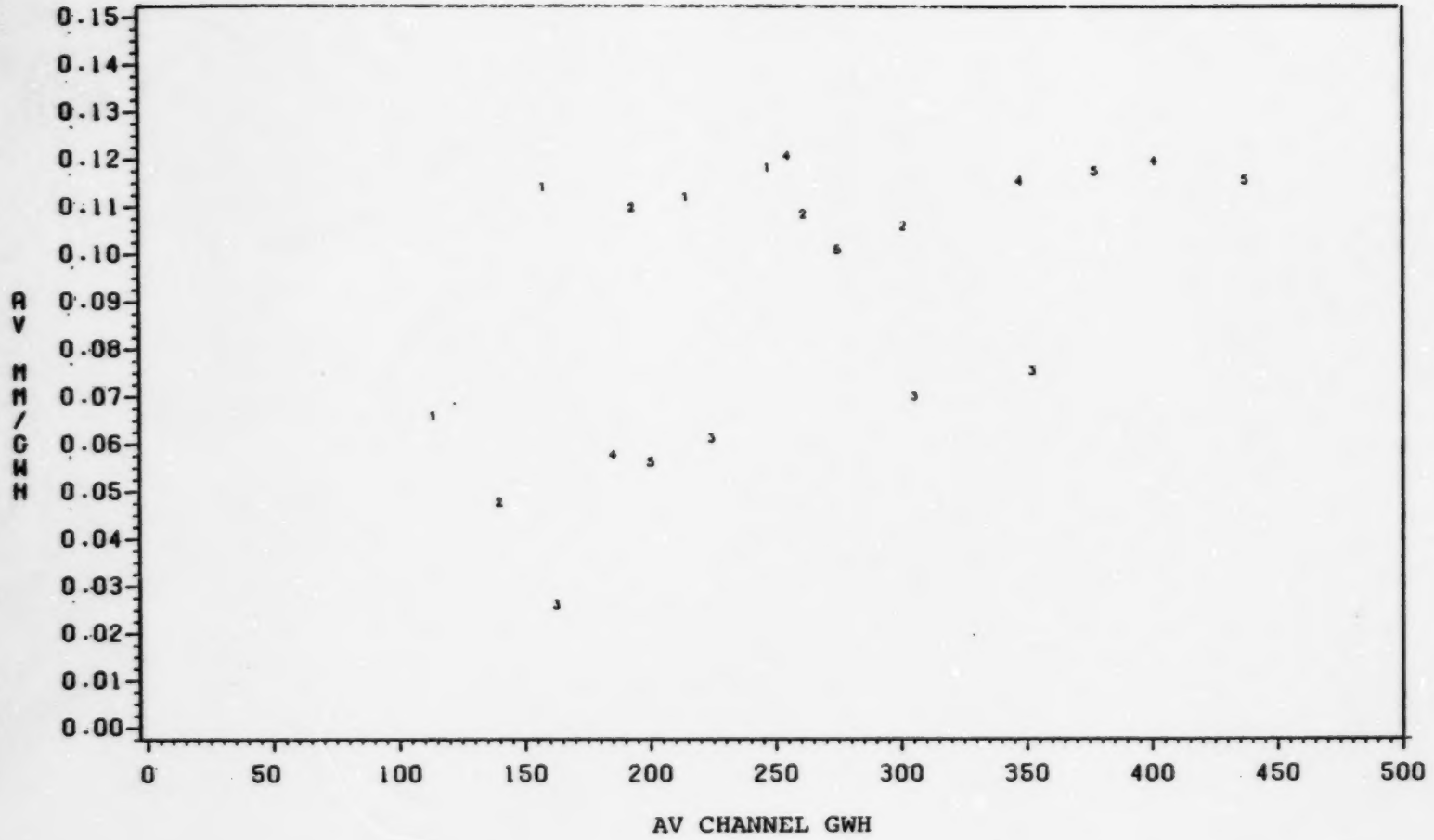

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FIGURE 13

PNGS–A BULK ELONGATION DATA
AVERAGE REGRESSION RATES
BY ZONES
UNIT=4

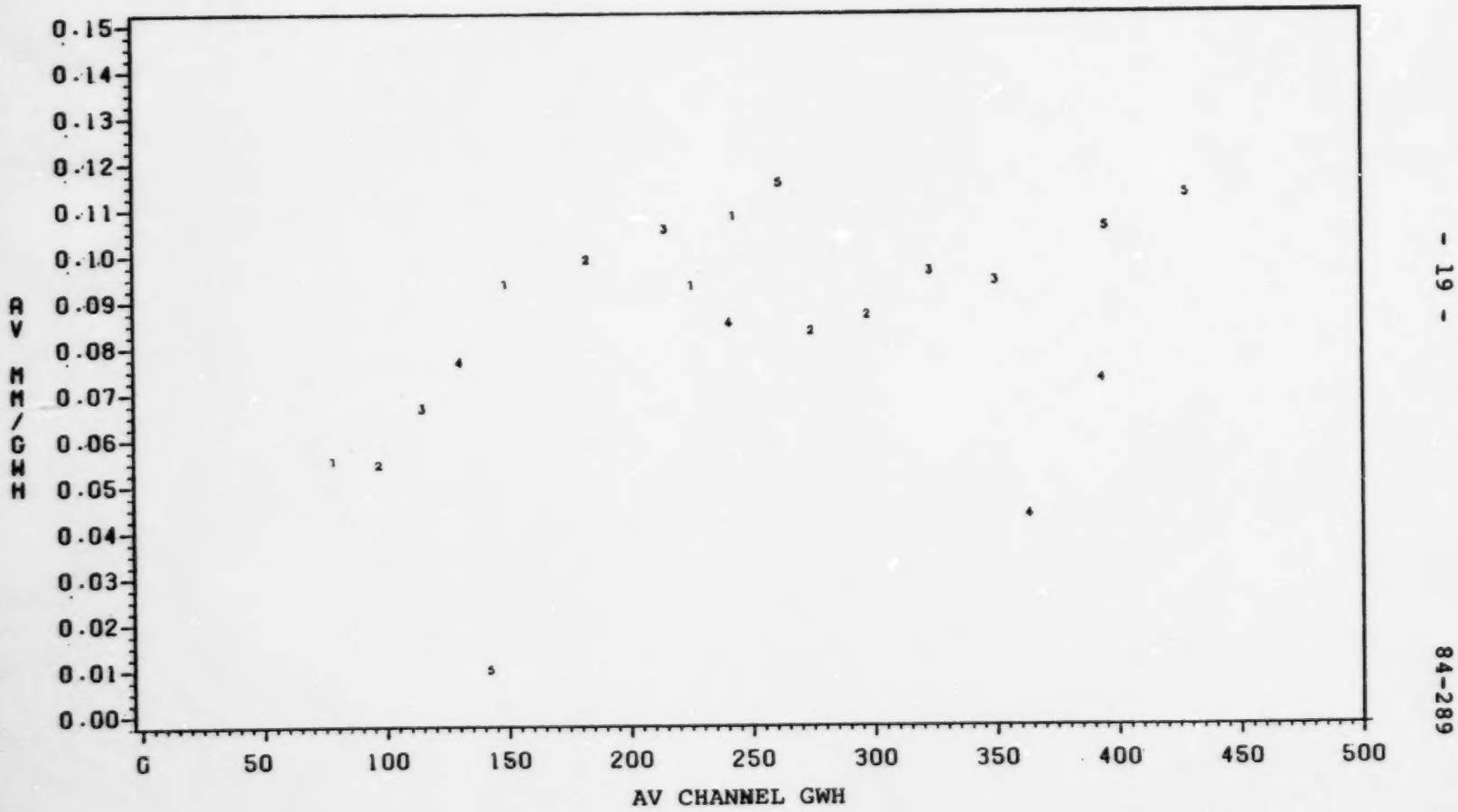

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FIGURE 14

PNGS-A BULK ELONGATION DATA
ALL MEASUREMENTS
UNIT=3

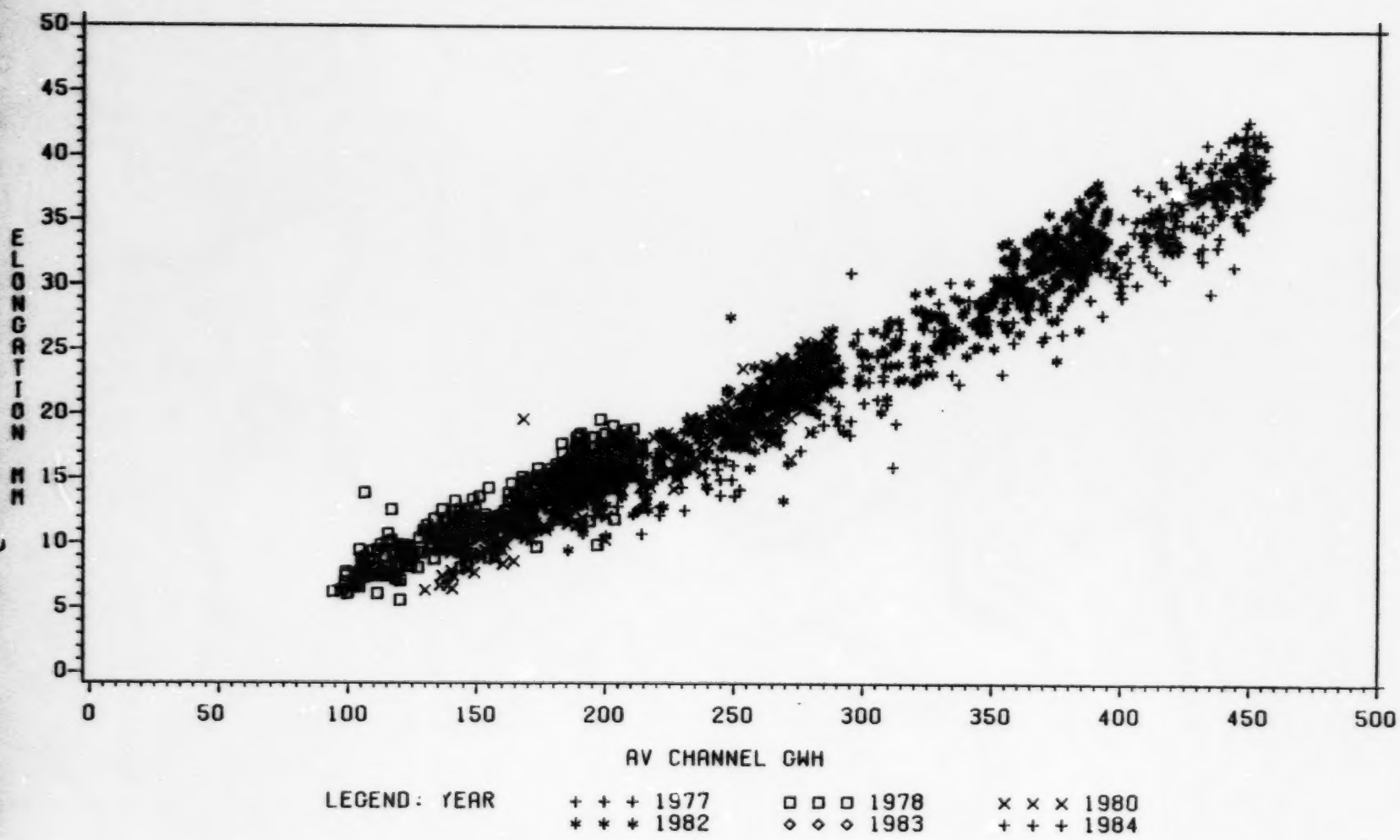

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FIGURE 15

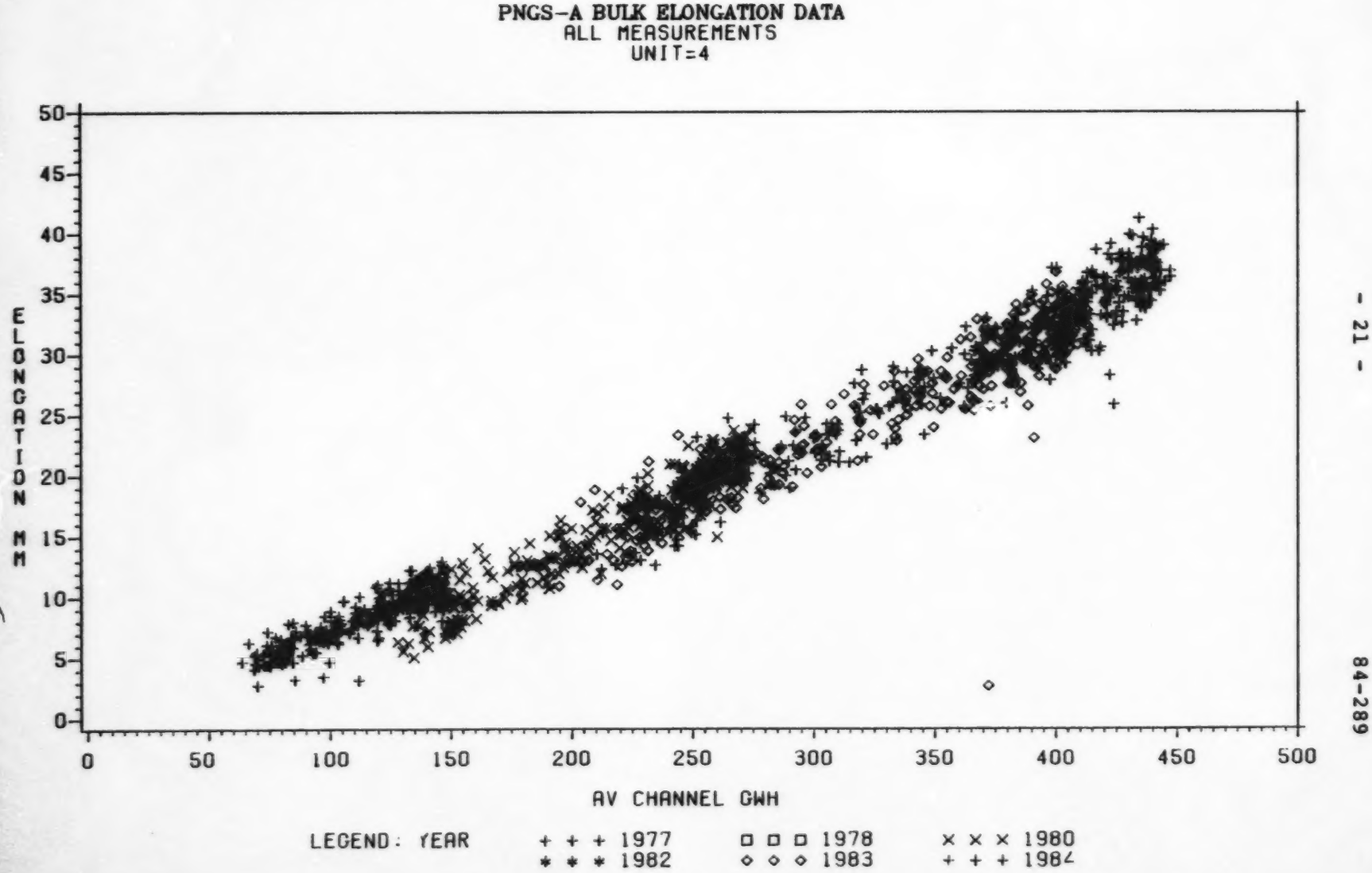

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TABLE 1

Measurement Dates

Station	Unit	Month*	Year	GWh	EFPH
P	3	May	1978	67235	38552
P	3	May	1980	92524	53053
P	3	October	1982	126396	72475
P	3	April	1984	146116	83782
P	4	September	1977	47321	27134
P	4	September	1980	87826	50359
P	4	November	1983	132497	75973
P	4	August	1984	143557	82315

* SORO Run Month

TABLE 2

Regression Analysis on Bulk Elongation Rates

Unit	Year	Intercept MM	SLOPE MM/GWH	SLOPE MM/7000 EFPH	R-SQUARE	
3	1978	-1.87	0.0909	2.89	0.84	
3	1980	-7.26	0.1090	3.45	0.93	(1),(2)
3	1982	-7.29	0.1054	3.32	0.91	(1),(2)
3	1984	-8.54	0.1047	3.30	0.93	(1),(2)
4	1977	-0.81	0.0808	2.73	0.76	
4	1980	-6.68	0.1046	3.40	0.91	(1),(2),(3)
4	1983	-6.09	0.0955	3.09	0.91	
4	1984	-7.62	0.1009	3.27	0.92	(1),(3)

Notes (1) A dummy regression analysis indicated no significant difference in slope between these measurements.

(2),(3) These regression lines agree in slope and intercept

TABLE 3

REGRESSION ANALYSIS ON BULK DATA BY ZONE

UNIT	YEAR	ZONE	INTERCEPTS	SLOPE		R-SQUARE
				mm/7000 EFPH	mm/GWH	
3	1978	1	.85	1.38	0.0658	0.21
3	1978	2	4.01	1.23	0.0476	0.13
3	1978	3	8.67	0.77	0.0260	0.07
3	1978	4	3.94	1.96	0.0576	0.19
3	1978	5	5.30	2.07	0.0560	0.09
3	1980	1	-8.04	2.40	0.1142	0.73
3	1980	2	-7.48	2.83	0.1098	0.52
3	1980	3	3.37	1.83	0.0611	0.28
3	1980	4	-10.69	4.10	0.1206	0.62
3	1980	5	-4.83	3.69	0.1008	0.35
3	1982	1	-8.58	2.35	0.1120	0.49
3	1982	2	-8.00	2.75	0.1083	0.33
3	1982	3	3.29	2.08	0.0690	0.28
3	1982	4	-11.46	3.90	0.1154	0.49
3	1982	5	-11.61	4.32	0.1174	0.34
3	1984	1	-11.69	2.46	0.1182	0.56
3	1984	2	-8.89	2.68	0.1059	0.38
3	1984	3	1.71	2.23	0.0752	0.35
3	1984	4	-15.16	4.04	0.1196	0.53
3	1984	5	-13.08	4.25	0.1156	0.38
4	1977	1	1.10	1.21	0.0555	0.14
4	1977	2	1.69	1.48	0.0546	0.08
4	1977	3	0.79	2.14	0.0669	0.08
4	1977	4	-0.32	2.79	0.6769	0.12
4	1977	5	9.31	0.39	0.0099	0.00
4	1980	1	-4.88	2.03	0.0938	0.26
4	1980	2	-5.83	2.62	0.0989	0.34
4	1980	3	-6.98	3.28	0.1055	0.45
4	1980	4	-2.36	2.97	0.0851	0.23
4	1980	5	-9.39	4.38	0.1155	0.34
4	1983	1	-5.72	1.99	0.0934	0.29
4	1983	2	-2.57	2.17	0.0835	0.40
4	1983	3	-6.25	2.95	0.0964	0.53
4	1983	4	11.98	1.50	0.0435	0.22
4	1983	5	-10.00	3.96	0.1059	0.27
4	1984	1	-9.49	2.30	0.1084	0.38
4	1984	2	-3.42	2.26	0.0870	0.37
4	1984	3	-5.29	2.87	0.0943	0.50
4	1984	4	-2.93	2.50	0.0729	0.23
4	1984	5	-12.75	4.22	0.1130	0.30

APPENDIX 1

The following computer programs are used to generate the programs and runstreams for integrating the SORO tapes, and generating microfiche of the fluence maps. Instructions are imbedded in the programs stores in 548116*SSG on the Univac 1182X.

```
*SORO
     1          :@SSG
     2          :SKEL
     3          :*.   THIS STREAM WILL GENERATE THE BATCH RUNSTREAMS
     4          :*.   TO READ SORO TAPES AND COPY THEM ON TO
     5          :*.   DISK STORAGE
     6          :*.
     7          :*.   THE FILES WILL BE NAMED AS
     8          :*.   [Q]*[S][U]-[MMM][YY].
     9          :*.   WHERE
    10          :*.    [Q] IS THE QUALIFIER AND IS
    11          :*.      TAKEN FROM THE 'Q' SGS CARD
    12          :*.    [S] IS THE FIRST LETTER OF THE
    13          :*.      STATION AND COMES FROM THE 'S' SGS CARD
    14          :*.    [U] IS THE UNIT NUMBER FROM THE 'U' SGS CARD
    15          :*.    [MMM] ARE THE FIRST 3 LETTERS OF THE MONTH
    16          :*.    [YY] ARE THE LAST 2 NUMBERS OF THE YEAR
    17          :*.       ON THE 'Y' SGS CARD
    18          :*.   THE TAPE IS IDENTIFIED BY THE FOLLOWWING
    19          :*.   THREE SGS CARDS:
    20          :*.   L - IS FOR LABEL TYPE, ONE OF 'F' OR 'J'
    21          :*.   D - IS FOR DENSITY, EITHER 'S' OR 'V'
    22          :*.   NO - IS FOR TAPE NUMBER
    23          :*.
    24          :*.   THIS STREAM ASSUMES THAT THE SORO TAPES ARE
    25          :*.   SPOOLED IN REVERSE ORDER AND THAT
    26          :*.   AN ENTIRE CALENDER YEAR EXISTS ON ONE
    27          :*.   TAPE, SO SOME EDITING MAY BE IN ORDER
    28          :*.   THE ELEMENT CALLED SORO2 IS SIMILAR TO THIS
    29          :*.   BUT ASSUMES THAT THE MASTER FILES ARE
    30          :*.   SPOOLED IN CALENDER ORDER AND SEPARATED BY
    31          :*.   A DUMMY FILE.
    32          :*.
    33          :*. USE:
    34          :*.    COPY THE FILE THAT CONTAINS THIS ELEMENT INTO TPF$
    35          :*.         I E @COPY   SSG.,TPF$.
    36          :*.    CHANGE THE SGS CARDS FOUND AFTER THE LINE
    37          :*.    THAT STARTS WITH 'SGS'
    38          :*.    EXECUTE THE ELEMENT-- @ADD SORO
    39          :*.    WHEN THE PROCESSING IS FINISHED
    40          :*.      MESSAGES WILL BE PRINTED SHOWING
    41          :*.      THE ELEMENT NAME CONTAINING
    42          :*.      THE GENERATED BATCH PROCEDURE
    43          :*.    RECOPY THE TPF$ FILE BACK TO THE ORIGINAL
    44          :*.     I E @COPY TPF$.,SSG.
    45          :*.    START THE RUNSTREAM ELEMENT IN SSG.
    46          :*.    I E @START SSG.ELNAME
    47          :*.
    48          :*.  THIS IS THE FIRST STREAM TO EXECUTE
    49          :*. IN THE PROCESS OF GENERATING FLUENCE MAPS:
    50          :*.
    51          :*. THE ORDER IS:
    52          :*.     RUN EITHER SORO OR SORO2 TO
    53          :*.      GENERATE THE SORO MASTERFILES
    54          :*.     RUN IBP TO INTEGRATE THE BUNDLEPOWERS
    55          :*.     DELETE THE SORO MASTERFILES WHEN THROUGH WITH THEM
```

```
*SORO
  56          :*.    RUN FLUENCE TO GENERATE THE FLUENCE MAPS
  57          :*.    RUN THE TAPES STREAM TO SPOOL THE
  58          :*.     INTEGRATED BUNDLE POWER FILES ONTO A TAPE
  59          :*.     FOR LONG TERM STORAGE
  60          :*.
  61          :*CREATE SGS: BRKPT1 CS[S,1,1,1][U,1,1,1][Y,1,1,1]
  62          :*CREATE SGS: BRKPT2 DS[S,1,1,1][U,1,1,1][Y,1,1,1]
  63          :*CREATE SGS: BRKPT3 BCS[S,1,1,1][U,1,1,1][Y,1,1,1]
  64          :*BRKPT    [BRKPT1,1,1,1]
  65          :*RUN,P     XLDCG,,[Q,1,1,1],30
  66          :*DELETE,C      [BRKPT3,1,1,1].
  67          :*CAT,P         [BRKPT3,1,1,1].
  68          :*BRKPT         PRINT$/[BRKPT3,1,1,1]
  69          :*ASG,T[L,1,1,1]    T.,U9[D,1,1,1],[NO,1,1,1]
  70          :*INCREMENT I FROM 12 TO 1 BY -1
  71          :*DELETE,C      [S,1,1,1][U,1,1,1]-[M,1,1,I][Y,1,1,1].
  72          :*CAT,P         [S,1,1,1][U,1,1,1]-[M,1,1,I][Y,1,1,1].,F/100//2000
  73          :*ASG,AX        [S,1,1,1][U,1,1,1]-[M,1,1,I][Y,1,1,1].
  74          :*COPY,G        T.,[S,1,1,1][U,1,1,1]-[M,1,1,I][Y,1,1,1].
  75          :*LOOP
  76          :*BRKPT         PRINT$
  77          :*SYM,U         [BRKPT3,1,1,1].,,[SYM,1,1,1]
  78          :*FIN
  79          :*BRKPT         [BRKPT2,1,1,1]
  80          :*INCREMENT I FROM 12 TO 1 BY -1
  81          :*DELETE,C      [S,1,1,1][U,1,1,1]-[M,1,1,I][Y,1,1,1].
  82          :*LOOP
  83          :*BRKPT
  84          :*MESSAGE,IT * THE ELEMENT CONTAINING THE RUNSTREAM IS [BRKPT1,1,1,1] *
  85          :*MESSAGE,IT * THE OUTPUT WILL BE BREAKPOINTED TO [Q,1,1,1]*[BRKPT3,1,1,1]. *
  86          :*MESSAGE,IT * AND SYMMED TO [SYM,1,1,1] *
  87          :*MESSAGE,IT * WHEN YOU WANT TO DELETE THE GENERATED SORO
  88          :*MESSAGE,IT   MASTERFILES @ADD THE ELEMENT [BRKPT2,1,1,1] *
  89          :@EOF
  90          :SGS
  91          :Q 548116
  92          :SYM RMSP35
  93          :S B
  94          :U 1
  95          :Y 83
  96          :NO 35908
  97          :L F
  98          :D S
  99          :M JAN,FEB,MAR,APR,MAY,JUN,JUL,AUG,SEP,OCT,NOV,DEC
 100          :@EOF
 101          :@EOF
```

```
*SORO2
     1          :@SSG
     2          :SKEL
     3          :*CREATE SGS: BRKPT1 CS[S,1,1,1][U,1,1,1][Y,1,1,1]
     4          :*CREATE SGS: BRKPT2 DS[S,1,1,1][U,1,1,1][Y,1,1,1]
     5          :*CREATE SGS: BRKPT3 BCS[S,1,1,1][U,1,1,1][Y,1,1,1]
     6          :*BRKPT    [BRKPT1,1,1,1]
     7          :*RUN,P     XLDCG,,[Q,1,1,1]
     8          :*DELETE,C      [BRKPT3,1,1,1].
     9          :*CAT,P         [BRKPT3,1,1,1].
    10          :*BRKPT         PRINT$/[BRKPT3,1,1,1]
    11          :*ASG,T[L,1,1,1]     T.,U9[D,1,1,1],[NO,1,1,1]
    12          :*INCREMENT I FROM 1 TO 12 BY 1
    13          :*DELETE,C      [S,1,1,1][U,1,1,1]-[M,1,1,I][Y,1,1,1].
    14          :*CAT,P         [S,1,1,1][U,1,1,1]-[M,1,1,I][Y,1,1,1].,F/50//1000
    15          :*ASG,AX        [S,1,1,1][U,1,1,1]-[M,1,1,I][Y,1,1,1].
    16          :*COPY,G        T.,[S,1,1,1][U,1,1,1]-[M,1,1,I][Y,1,1,1].
    17          :*MOVE          T.,1
    18          :*LOOP
    19          :*BRKPT         PRINT$
    20          :*SYM,U         [BRKPT3,1,1,1].,,[SYM,1,1,1]
    21          :*FIN
    22          :*BRKPT         [BRKPT2,1,1,1]
    23          :*INCREMENT I FROM 12 TO 1 BY -1
    24          :*DELETE,C      [S,1,1,1][U,1,1,1]-[M,1,1,I][Y,1,1,1].
    25          :*LOOP
    26          :*BRKPT
    27          :*MESSAGE,IT * THE ELEMENT CONTAINING THE RUNSTREAM IS [BRKPT1,1,1,1] *
    28          :*MESSAGE,IT * THE OUTPUT WILL BE BREAKPOINTED TO [Q,1,1,1]*[BRKPT3,1,1,1]. *
    29          :*MESSAGE,IT * AND SYMMED TO [SYM,1,1,1] *
    30          :*MESSAGE,IT * WHEN YOU WANT TO DELETE THE GENERATED SORO
    31          :*MESSAGE,IT   MASTERFILES @ADD THE ELEMENT [BRKPT2,1,1,1] *
    32          :@EOF
    33          :SGS
    34          :S B
    35          :U 1
    36          :Y 82
    37          :NO 55443
    38          :L F
    39          :D S
    40          :Q 548116
    41          :SYM RMSP35
    42          :M JAN,FEB,MAR,APR,MAY,JUN,JUL,AUG,SEP,OCT,NOV,DEC
    43          :@EOF
    44          :@EOF
```

```
¤IBP
     1          :@SSG
     2          :$KEL
     3          :¤.
     4          :¤. THIS STREAM GENERATES THE BATCH RUN
     5          :¤. TO INTEGRATE THE BUNDLE POWERS
     6          :¤. FROM THE SORO MASTER FILES
     7          :¤.
     8          :¤. THE MASTER FILES MUST BE ON LINE AND
     9          :¤. NAMED [Q]¤[S][U]-[MMM][YY] WHERE
    10          :¤.   [Q] IS THE QUALIFIER AND IS
    11          :¤.     TAKEN FROM THE 'Q' SGS CARD
    12          :¤.   [S] IS THE FIRST LETTER OF THE
    13          :¤.     STATION AND COMES FROM THE 'S' SGS CARD
    14          :¤.   [U] IS THE UNIT NUMBER FROM THE 'U' SGS CARD
    15          :¤.   [MMM] ARE THE FIRST 3 LETTERS OF THE MONTH
    16          :¤.   [YY] ARE THE LAST 2 NUMBERS OF THE YEAR
    17          :¤.
    18          :¤.  THERE MUST BE TWO SETS OF 'M' AND 'Y' SGS CARDS
    19          :¤.  CORRESPONDING TO THE STARTING AND ENDING MONTH AND
    20          :¤.  YEAR FOR WHICH BUNDLE POWERS WILL BE INTEGRATED
    21          :¤.  NOTE:
    22          :¤.    THE STARTING DATE MUST BE 1 MONTH EARLIER THAN DESIRED
    23          :¤.    THUS IF DEC 82 IS THE FIRST INTEGRATION TO BE PERFORMED
    24          :¤.    SET THE
    25          :¤.    FIRST M AND Y CARDS TO NOV 82 RESPECTIVELY
    26          :¤.
    27          :¤. USE:
    28          :¤.   COPY THE FILE THAT CONTAINS THIS ELEMENT INTO TPF$
    29          :¤.        I E @COPY   SSG.,TPF$.
    30          :¤.   CHANGE THE SGS CARDS FOUND AFTER THE LINE
    31          :¤.   THAT STARTS WITH SGS
    32          :¤.   EXECUTE THE ELEMENT-- @ADD IBP
    33          :¤.   WHEN THE PROCESSING IS FINISHED
    34          :¤.     MESSAGES WILL BE PRINTED SHOWING
    35          :¤.     THE ELEMENT NAME CONTAINING
    36          :¤.     THE GENERATED BATCH PROCEDURE
    37          :¤.   RECOPY THE TPF$ FILE BACK TO THE ORIGINAL
    38          :¤.    I E @COPY TPF$.,SSG.
    39          :¤.   START THE RUNSTREAM ELEMENT IN SSG.
    40          :¤.   I E @START SSG.ELNAME
    41          :¤.
    42          :¤DEFINE GMN
    43          :¤INCREMENT J FROM 1 TO 12
    44          :¤IF [¤1] = [MO,1,1,J]
    45          :¤SET [¤2] TO J
    46          :¤END
    47          :¤LOOP
    48          :¤END
    49          :¤DEFINE CRT
    50          :¤DELETE,C      [¤1].
    51          :¤IF [¤2]
    52          :¤CAT,P         [¤1].,[¤2]
    53          :¤ELSE
    54          :¤CAT,P         [¤1].
    55          :¤END
```

```
*IBP
  56        :*END
  57        :*DEFINE ASG
  58        :*IF [#2]
  59        :#FREE          [#2].
  60        :#ASG,AX        [#1].
  61        :#USE           [#2].,[#1].
  62        :*ELSE
  63        :#ASG,AX        [#1].
  64        :*END
  65        :*END
  66        :*DEFINE XQT
  67        :#XQT           FASF.ABS
  68        :[#1]NGS-A UNIT [#2] BUNDLE POWER - [M0,1,1,I] [#3]
  69        :    [#1][#2]    1    [#3]    [MNC,1,1,I]
  70        :#FREE          8.
  71        :#FREE          9.
  72        :#FREE          10.
  73        :#FREE          11.
  74        :*END
  75        :*CREATE SGS: BRKPT1 CIBP[S,1,1,1][U,1,1,1][Y,2,1,1]
  76        :*CREATE SGS: BRKPT2 BIBP[S,1,1,1][U,1,1,1][Y,2,1,1]
  77        :*BRKPT         [BRKPT1,1,1,1]
  78        :#RUN,N/TP XL[S,1,1,1][U,1,1,1][Y,1,1,1],,[Q,1,1,1],240,1000
  79        :#DELETE,C      [BRKPT2,1,1,1].
  80        :#CAT,P         [BRKPT2,1,1,1].
  81        :#BRKPT         PRINT$/[BRKPT2,1,1,1]
  82        :*CLEAR M1
  83        :*PROCESS GMN [M,1,1,1] M1
  84        :*CLEAR M2
  85        :*PROCESS GMN [M,2,1,1] M2
  86        :*SET Y1 TO [Y,1,1,1]
  87        :*SET Y2 TO [Y,2,1,1]
  88        :*IF +Y2 = Y1
  89        :*SET KOUNT TO M2-M1
  90        :*ELSE
  91        :*SET KOUNT TO 12-M1+M2
  92        :*SET Y3 TO Y2-Y1-1
  93        :*IF +Y3 < 0
  94        :*CLEAR Y3
  95        :*END
  96        :*MULTIPLY Y3 BY 12 GIVING Y3
  97        :*SET KOUNT TO Y3+KOUNT
  98        :*END
  99        :*SET YR TO Y1
 100        :*SET I TO M1
 101        :*CREATE SGS: IF IF[S,1,1,1][U,1,1,1]-[M0,1,1,I][*YR]
 102        :*INCREMENT NUM FROM 1 TO KOUNT
 103        :*PROCESS ASG [IF,1,1,1] 9
 104        :*REMOVE SGS IF
 105        :*SET I TO +I+1
 106        :*IF +I > 12
 107        :*SET I TO +1
 108        :*SET YR TO +YR+1
 109        :*END
 110        :*CREATE SGS: SORO [S,1,1,1][U,1,1,1]-[M0,1,1,I][*YR]
 111        :*PROCESS ASG [SORO,1,1,1] 8
 112        :*REMOVE SGS SORO
```

```
*IBP

  113         :*CREATE SGS: IF IF[S,1,1,1][U,1,1,1]-[MO,1,1,I][*YR]
  114         :*CREATE SGS: DEL DEL[S,1,1,1][U,1,1,1]-[MO,1,1,I][*YR]
  115         :*PROCESS CRT [IF,1,1,1]
  116         :*PROCESS ASG [IF,1,1,1] 10
  117         :*PROCESS CRT [DEL,1,1,1]
  118         :*PROCESS ASG [DEL,1,1,1] 11
  119         :*PROCESS XQT [S,1,1,1] [U,1,1,1] +YR
  120         :*REMOVE SGS DEL
  121         :*LOOP
  122         :*BRKPT PRINT$
  123         :*SYM,U         [BRKPT2,1,1,1].,,QPR
  124         :*FIN
  125         :*MESSAGE,IT * THE ELEMENT CONTAINING THE RUNSTREAM IS [BRKPT1,1,1,1] *
  126         :*MESSAGE,IT * THE OUTPUT WILL BE BREAKPOINTED TO [Q,1,1,1]*[BRKPT2,1,1,1] *
  127         :*BRKPT
  128         :@EOF
  129         :SGS
  130         :Q 548116
  131         :S B
  132         :U 1
  133         :M JAN
  134         :Y 77
  135         :M DEC
  136         :Y 77
  137         :MO JAN,FEB,MAR,APR,MAY,JUN,JUL,AUG,SEP,OCT,NOV,DEC
  138         :MNC 01,02,03,04,05,06,07,08,09,10,11,12
  139         :@EOF
  140         :@EOF
```

```
*FLUENCE
  1         :@SSG
  2         :SKEL
  3         :*.
  4         :*. THIS STREAM WILL GENERATE THE BATCH RUNSTREAMS
  5         :*. TO CONVERT INTEGRATED BUNDLE POWER FILES
  6         :*. TO FLUENCE
  7         :*.  MICROFICHE WILL BE GENERATED
  8         :*.
  9         :*. THE BUNDLE POWER FILES MUST BE ON LINE AND
 10         :*. NAMED  [Q]*IF[S][U]-[MMM][YY]
 11         :*. GENERATION OF THESE FILES IS DONE IN THE
 12         :*. IBP ELEMENT
 13         :*.   [Q] IS THE QUALIFIER AND IS
 14         :*.     TAKEN FROM THE 'Q' SGS CARD
 15         :*.   [S] IS THE FIRST LETTER OF THE
 16         :*.     STATION AND COMES FROM THE 'S' SGS CARD
 17         :*.   [U] IS THE UNIT NUMBER FROM THE 'U' SGS CARD
 18         :*.   [MMM] ARE THE FIRST 3 LETTERS OF THE MONTH
 19         :*.   [YY] ARE THE LAST 2 NUMBERS OF THE YEAR
 20         :*. MMM AND YY CORRESPOND TO THE STARTING  AND ENDING
 21         :*. MONTH AND YEAR DEFINED IN THE
 22         :*. 'M' AND 'Y' CARDS
 23         :*. THERE MUST BE TWO SETS OF THE M AND Y CARDS
 24         :*. AND THE SECOND SET MUST BE HIGHER IN
 25         :*. CALENDER SEQUENCE THAN THE FIRST
 26         :*.
 27         :*. USE:
 28         :*.   COPY THE FILE THAT CONTAINS THIS ELEMENT INTO TPF$
 29         :*.        I E @COPY   SSG.,TPF$.
 30         :*.   CHANGE THE SGS CARDS FOUND AFTER THE LINE
 31         :*.   THAT STARTS WITH 'SGS'
 32         :*.   EXECUTE THE ELEMENT-- @ADD FLUENCE
 33         :*.   WHEN THE PROCESSING IS FINISHED
 34         :*.     MESSAGES WILL BE PRINTED SHOWING
 35         :*.     THE ELEMENT NAME CONTAINING
 36         :*.     THE GENERATED BATCH PROCEDURE
 37         :*.   RECOPY THE TPF$ FILE BACK TO THE ORIGINAL
 38         :*.    I E @COPY TPF$.,SSG.
 39         :*.   START THE RUNSTREAM ELEMENT IN SSG.
 40         :*.   I E @START SSG.ELNAME
 41         :*.
 42         :*DEFINE GMN
 43         :*. CONVERT A 3 LETTER MONTH NAME TO THE
 44         :*.   THE CORRESPONDING MONTH NUMBER (1-12)
 45         :*INCREMENT J FROM 1 TO 12
 46         :*IF [#1] = [MO,1,1,J]
 47         :*SET [#2] TO J
 48         :*END
 49         :*LOOP
 50         :*END
 51         :*DEFINE CRT
 52         :#DELETE,C      [#1].
 53         :*IF [#2]
 54         :#CAT,P         [#1].,[#2]
 55         :*ELSE
```

```
*FLUENCE
  56          :*CAT,P          [*1].
  57          :*END
  58          :*END
  59          :*DEFINE ASG
  60          :*IF [*2]
  61          :*FREE           [*2].
  62          :*ASG,AX         [*1].
  63          :*USE            [*2].,[*1].
  64          :*ELSE
  65          :*ASG,AX         [*1].
  66          :*END
  67          :*END
  68          :*CREATE SGS: BRKPT1 FL[S,1,1,1][U,1,1,1]
  69          :*CREATE SGS: BRKPT2 FL[S,1,1,1][U,1,1,1]
  70          :*BRKPT           [BRKPT],1,1,1]
  71          :*RUN,P/TP XL[S,1,1,1][U,1,1,1][Y,1,1,1],,[Q,1,1,1],30,2000
  72          :*DELETE,C        [BRKPT2,1,1,1].
  73          :*CAT,P           [BRKPT2,1,1,1].,F/100//2000
  74          :*BRKPT           PRINT$/[BRKPT2,1,1,1]
  75          :*HDG       .N,66,6,3
  76          :*EDIT ON
  77          :*LOG FAST NEUTRON FLUENCE&
  78          :*SET COLED$ TO 73
  79          :. *
  80          :*EDIT ON
  81          :*LOG [S,1,1,1]NGS-A UNIT [U,1,1,1]&
  82          :*SET COLED$ TO 35
  83          :[N,1,1,1] [Y,1,1,1]&
  84          :*SET COLED$ TO 73
  85          :. **
  86          :*EDIT ON
  87          :*LOG K=[K,1,1,1] (N/CM**2)/(KWH/CM)&
  88          :*SET COLED$ TO 35
  89          :[N,2,1,1] [Y,2,1,1]&
  90          :*SET COLED$ TO 73
  91          :. ***
  92          :*EDIT OFF
  93          :*PRT,S FASF.MAIN,.FLUX,.PRINT1
  94          :*CLEAR M1
  95          :*PROCESS GMN [N,1,1,1] M1
  96          :*CLEAR M2
  97          :*PROCESS GMN [N,2,1,1] M2
  98          :*SET Y1 TO [Y,1,1,1]
  99          :*SET Y2 TO [Y,2,1,1]
 100          :*IF +Y2 = Y1
 101          :*SET KOUNT TO M2-M1
 102          :*ELSE
 103          :*SET KOUNT TO 12-M1+M2
 104          :*SET Y3 TO Y2-Y1-1
 105          :*IF +Y3 < 0
 106          :*CLEAR Y3
 107          :*END
 108          :*MULTIPLY Y3 BY 12 GIVING Y3
 109          :*SET KOUNT TO Y3+KOUNT+1
 110          :*END
 111          :*SET YR TO Y1
 112          :*SET I TO M1
```

```
#FLUENCE

113         :#CREATE SGS: IF IF[S,1,1,1][U,1,1,1]-[MO,1,1,I][#YR]
114         :#INCREMENT NUM FROM 1 TO KOUNT
115         :#PROCESS ASG [IF,1,1,1] 9
116         :#REMOVE SGS IF
117         :#SET I TO +I+1
118         :#IF +I > 12
119         :#SET I TO +1
120         :#SET YR TO +YR+1
121         :#END
122         :#CREATE SGS: IF IF[S,1,1,1][U,1,1,1]-[MO,1,1,I][#YR]
123         :#XQT           FASF.FLUX
124         :#LOOP
125         :#BRKPT PRINT$
126         :#ASG,TFVR FLT.,U9V,,30
127         :#COPY,F [BRKPT2,1,1,1].,FLT
128         :#PRINT,M FLT.,SUB405
129         :1 ORIGINAL + 2 COPIES
130         :#SYM [BRKPT2,1,1,1].,,QPR
131         :#FIN
132         :#BRKPT
133         :#MESSAGE,IT THE RUNSTREAM ELEMENT IS [BRKPT1,1,1,1]
134         :#MESSAGE,IT WHEN THE RUN IS STARTED THE OUTPUT
135         :#MESSAGE,IT WILL BE IN FILE [Q,1,1,1]#[BRKPT2,1,1,1]
136         :@EOF
137         :SGS
138         :S B
139         :U 2
140         :K '2.18'
141         :M DEC
142         :Y 82
143         :M DEC
144         :Y 83
145         :Q 548116
146         :MO JAN,FEB,MAR,APR,MAY,JUN,JUL,AUG,SEP,OCT,NOV,DEC
147         :MNC 01,02,03,04,05,06,07,08,09,10,11,12
148         :@EOF
149         :@EOF
```

```
*TAPES
  1         :@SSG
  2         :SKEL
  3         :*.  USE THIS STREAM TO SPOOL THE?
  4         :*.  INTEGRATED BUNDLE POWER FILES ONTO TAPE
  5         :*.
  6         :*. THE BUNDLE POWER FILES MUST BE ON LINE AND
  7         :*. NAMED  [Q]*IF[S][U]-[MMM][YY]
  8         :*. GENERATION OF THESE FILES IS DONE IN THE
  9         :*. IBP ELEMENT
 10         :*.   [Q] IS THE QUALIFIER AND IS
 11         :*.     TAKEN FROM THE 'Q' SGS CARD
 12         :*.   [S] IS THE FIRST LETTER OF THE
 13         :*.     STATION AND COMES FROM THE 'S' SGS CARD
 14         :*.   [U] IS THE UNIT NUMBER FROM THE 'U' SGS CARD
 15         :*.   [MMM] ARE THE FIRST 3 LETTERS OF THE MONTH
 16         :*.   [YY] ARE THE LAST 2 NUMBERS OF THE YEAR
 17         :*. MMM AND YY CORRESPOND TO THE STARTING  AND ENDING
 18         :*. MONTH AND YEAR DEFINED IN THE
 19         :*. 'M' AND 'Y' CARDS
 20         :*. THERE MUST BE TWO SETS OF THE M AND Y CARDS
 21         :*. AND THE SECOND SET MUST BE HIGHER IN
 22         :*. CALENDER SEQUENCE THAN THE FIRST
 23         :*.
 24         :*. USE:
 25         :*.   COPY THE FILE THAT CONTAINS THIS ELEMENT INTO TPF$
 26         :*.       I E @COPY   SSG.,TPF$.
 27         :*.   CHANGE THE SGS CARDS FOUND AFTER THE LINE
 28         :*.   THAT STARTS WITH 'SGS'
 29         :*.   EXECUTE THE ELEMENT-- @ADD TAPES
 30         :*.   WHEN THE PROCESSING IS FINISHED
 31         :*.     MESSAGES WILL BE PRINTED SHOWING
 32         :*.     THE ELEMENT NAME CONTAINING
 33         :*.     THE GENERATED BATCH PROCEDURE
 34         :*.   RECOPY THE TPF$ FILE BACK TO THE ORIGINAL
 35         :*.    I E @COPY TPF$.,SSG.
 36         :*.   START THE RUNSTREAM ELEMENT IN SSG.
 37         :*.   I E @START SSG.ELNAME
 38         :*.
 39         :*DEFINE GMM
 40         :*INCREMENT J FROM 1 TO 12
 41         :*IF [*1] = [NO,1,1,J]
 42         :*SET [*2] TO J
 43         :*END
 44         :*LOOP
 45         :*END
 46         :*DEFINE CRT
 47         :*DELETE,C      [*1].
 48         :*IF [*2]
 49         :*CAT,P         [*1].,[*2]
 50         :*ELSE
 51         :*CAT,P         [*1].
 52         :*END
 53         :*END
 54         :*DEFINE ASG
 55         :*IF [*2]
```

```
*TAPES

  56          :*FREE          [*2].
  57          :*ASG,AX        [*1].
  58          :*USE           [*2].,[*1].
  59          :*ELSE
  60          :*ASG,AX        [*1].
  61          :*END
  62          :*END
  63          :*CREATE SGS: BRKPT1 IFT[S,1,1,1][U,1,1,1]
  64          :*BRKPT         [BRKPT1,1,1,1]
  65          :*RUN,P/T XLT[S,1,1,1][U,1,1,1],,[Q,1,1,1],20
  66          :*SYM PRINT$.,,[SYM,1,1,1]
  67          :*ASG,TFSR IF[S,1,1,1][U,1,1,1]TAPE.,U9S,,1700
  68          :*CLEAR M1
  69          :*PROCESS GMN [M,1,1,1] M1
  70          :*CLEAR M2
  71          :*PROCESS GMN [M,2,1,1] M2
  72          :*SET Y1 TO [Y,1,1,1]
  73          :*SET Y2 TO [Y,2,1,1]
  74          :*IF +Y2 = Y1
  75          :*SET KOUNT TO M2-M1
  76          :*ELSE
  77          :*SET KOUNT TO 12-M1+M2
  78          :*SET Y3 TO Y2-Y1-1
  79          :*IF +Y3 < 0
  80          :*CLEAR Y3
  81          :*END
  82          :*MULTIPLY Y3 BY 12 GIVING Y3
  83          :*SET KOUNT TO Y3+KOUNT+1
  84          :*END
  85          :*SET YR TO Y1
  86          :*SET I TO M1
  87          :*INCREMENT NUM FROM 1 TO KOUNT
  88          :*CREATE SGS: IF IF[S,1,1,1][U,1,1,1]-[MO,1,1,I][*YR]
  89          :*COPY,G [IF,1,1,1].,IF[S,1,1,1][U,1,1,1]TAPE.
  90          :*REMOVE SGS IF
  91          :*SET I TO +I+1
  92          :*IF +I > 12
  93          :*SET I TO +1
  94          :*SET YR TO +YR+1
  95          :*END
  96          :*LOOP
  97          :*FIN
  98          :*BRKPT
  99          :*MESSAGE,IT * THE RUNSTREAM ELEMENT IS [BRKPT1,1,1,1] *
 100          :*MESSAGE,IT * THE OUTPUT WILL BE SYMMED TO [SYM,1,1,1] *
 101          :*MESSAGE,IT * A TAPE WILL BE CREATED NAMED [Q,1,1,1]*IF[S,1,1,1][U,1,1,1]TAP
 102          :@EOF
 103          :SGS
 104          :S B
 105          :U 2
 106          :M DEC
 107          :Y 82
 108          :M DEC
 109          :Y 83
 110          :Q 548116
 111          :SYM RMSP35
 112          :MO JAN,FEB,MAR,APR,MAY,JUN,JUL,AUG,SEP,OCT,NOV,DEC
```

```
=TAPES

 113          :MNC 01,02,03,04,05,06,07,08,09,10,11,12
 114          :@EOF
 115          :@EOF
```

NOTE: The following files are
found in the File CHECKS

```
@TOC,TS CHECKS.
TOC 12R2      74R1H1 08/24/84 13:14:38

FILE: 548114*CHECKS(1)

ELT     CONV(2)
ELT     FNF(8)
ELT     FNFNU(2)
ELT     PRINTE149(1)
ELT     RSMF(1)
```

```
*CONV

    1          :C  THIS PROGRAM CONVERTS
    2          :C E SERIES TO T SERIES FORTRAN V
    3          :C
    4          :C  ASSIGN THE E SERIES FILE TO UNIT 10
    5          :C  ASSIGN THE EMPTY T SERIES FILE TO UNIT 11
    6          :C
    7          :       CALL F8TEN(10,11,1,$100,K)
    8          : 100    CONTINUE
    9          :       STOP
   10          :       END
```

```
*FNF
      1          :C
      2          :C  THIS PROGRAM READS AN INTEGRATED BUNDLE POWER
      3          :C  FILE OF THE FORM IF[S][U]-[MMM][YY]
      4          :C  FOR PNGS
      5          :C  ASSIGNED TO UNIT 10
      6          :C  AND PRINTS OUT SUMMARY STATISTICS
      7          :C  THE DIFFERENCE BETWEEN FNF AND FNFNU
      8          :C  IS THAT FNFNU HANDLES FILES WHICH DO NOT
      9          :C  HAVE A SEPERATE UNIT FIELD AFTER THE STATION
     10          :C  DESIGNATOR
     11          :C
     12          :       DOUBLE PRECISION TCPS,TSPS
     13          :       DIMENSION SPS1(24,24,12),CPS1(24,24)
     14          :       READ(10)STAID,IUNIT,IYEAR,IMONTH,GWHI,GWH2
     15          :       WRITE(6,20)STAID,IUNIT,IYEAR,IMONTH,GWHI,GWH2
     16          :       READ(10)(((SPS1(I,J,K),I=1,24),J=1,24),K=1,12)
     17          :       READ(10)(((CPS1(I,J),I=1,24),J=1,24))
     18          :C
     19          :C
     20          :       TSPS=0.
     21          :       TCPS=0.
     22          :       DO 100 J=1,24
     23          :       DO 100 I=1,24
     24          :       TCPS=TCPS+CPS1(I,J)
     25          : 100   CONTINUE
     26          :C
     27          :       FNF=TCPS*2.18E12/(12.*49.5*390.)
     28          :       TCPSAV=TCPS*1.744/(3600.*GWH2)
     29          :C
     30          :       FNFE=2.18E12*3600.*GWH2*1.E6/(390.*12.*49.5)
     31          :       ERR=100.*(FNF-FNFE)/FNFE
     32          :C
     33          :       WRITE(6,30)TCPS,TCPSAV,FNF,FNFE,ERR
     34          :C
     35          :       STOP
     36          :C
     37          : 20    FORMAT(1X,A6,1X,I6,1X,I5,1X,I5,2(1X,E15.7))
     38          : 30    FORMAT(' TOTAL CH.PW. = ',E14.7,
     39          :      1' AV CH.PW. = ',E14.7//
     40          :      2' AV CH FNF = ',E14.7,
     41          :      3' EXPECTED = ',E14.7,
     42          :      4' ERROR = ',F10.3)
     43          :       END
```

```
*FNFNU

:C
:C  THIS PROGRAM READS AN INTEGRATED BUNDLE POWER
:C  FILE OF THE FORM IF[S][U]-[MMM][YY]
:C  FOR PNGS
:C  ASSIGNED TO UNIT 10
:C  AND PRINTS OUT SUMMARY STATISTICS
:C  THE DIFFERENCE BETWEEN FNF AND FNFNU
:C  IS THAT FNFNU HANDLES FILES WHICH DO NOT
:C  HAVE A SEPERATE UNIT FIELD AFTER THE STATION
:C  DESIGNATOR
:C
      DOUBLE PRECISION TCPS,TSPS
      DIMENSION SPS1(24,24,12),CPS1(24,24)
      READ(10)STAID,IYEAR,IMONTH,GWHI,GWH2
      WRITE(6,20)STAID,IYEAR,IMONTH,GWHI,GWH2
      READ(10)(((SPS1(I,J,K),I=1,24),J=1,24),K=1,12)
      READ(10)(((CPS1(I,J),I=1,24),J=1,24))
:C
:C
      TSPS=0.
      TCPS=0.
      DO 100 J=1,24
      DO 100 I=1,24
      TCPS=TCPS+CPS1(I,J)
  100 CONTINUE
:C
      FNF=TCPS*2.18E12/(12.*49.5*390.)
      TCPSAV=TCPS*1.744/(3600.*GWH2)
:C
      FNFE=2.18E12*3600.*GWH2*1.E6/(390.*12.*49.5)
      ERR=100.*(FNF-FNFE)/FNFE
:C
      WRITE(6,30)TCPS,TCPSAV,FNF,FNFE,ERR
:C
      STOP
:C
   20 FORMAT(1X,A6,1X,1X,I5,1X,I5,2(1X,E15.7))
   30 FORMAT(' TOTAL CH.PW. = ',E14.7,
     1' AV CH.PW. = ',E14.7//
     2' AV CH FNF = ',E14.7,
     3' EXPECTED = ',E14.7,
     4' ERROR = ',F10.3)
      END
```

```
*PRINTE149

      1         :C  THIS PROGRAM REWRITES AN INTEGRATED BUNDLE POWER FILE
      2         :C  TO E14.9 FORMAT FOR CONVERSION FROM UNIVAC TO IBM
      3         :C
      4         :C  THE BUNDLE POWERS ARE READ AND THEN NOT USED
      5         :C  THE CHANNEL POWERS ARE READ AND CONVERTED
      6         :C  TO FLUENCE AND PRINTED ON UNIT 11 IN
      7         :C  E14.9 FORMAT
      8         :C
      9         :C  THE INTEGRATED BUNDLE POWER FILE MUST BE
     10         :C  ASSIGNED TO UNIT 10
     11         :C
     12         :C  NOTE:
     13         :C  AS SOME OF THE IBP FILES DO NOT HAVE A UNIT
     14         :C  FIELD, IT MAY BE NECESSARY TO REMOVE ANY REFERENCE
     15         :C  TO UNIT IN THE I/O STATEMENTS OF THIS PROGRAM
     16         :C  (THESE FILES HAVE THE UNIT EMBEDDED IN THE STAID FIELD)
     17         :C
     18         :C  THIS PROGRAM IS SET UP FOR PNGS
     19         :C
     20         :       INTEGER UNIT,YEAR,MONTH
     21         :       DIMENSION BP(24,24,12),CP(24,24)
     22         :       DATA CONST/2.18E12/
     23         :C
     24         :       READ(10) STAID,UNIT,YEAR,MONTH,GWH1,GWH2
     25         :       READ(10)(((BP(I,J,K),I=1,24),J=1,24),K=1,12)
     26         :       READ(10)((CP(I,J),I=1,24),J=1,24)
     27         :C
     28         :       DO 10 I=1,24
     29         :       DO 10 J=1,24
     30         :       CP(I,J)=CP(I,J)*CONST/(12.*49.5)
     31         : 10    CONTINUE
     32         :C
     33         :       WRITE(11,99)STAID,UNIT,YEAR,MONTH,GWH2
     34         :C
     35         : 99    FORMAT(1X,A6,1X,I1,1X,I4,1X,I4)
     36         :C
     37         :       DO 11 I=1,24
     38         : 11    WRITE(11,100)(CP(I,J),J=1,24)
     39         : 100   FORMAT(3(6(1X,E14.9)/),6(1X,E14.9))
     40         :       STOP
     41         :C
     42         :       END
```

```
*RSMF

     1          :C
     2          :C  THIS PROGRAM READS A SORO MASTER FILE
     3          :C   ASSIGNED TO UNIT 8
     4          :C  AND PRINTS THE HEADER FROM EACH DATA BLOCK
     5          :C
     6          :       INTEGER STSH
     7          :       DIMENSION DATA(9408)
     8          :  10   CONTINUE
     9          :       READ(8,END=50)NW,STSH,ISTN,ELG,IST,LDB,IDATE,GWHR,XNRM,
    10          :      1(DATA(I),I=1,LDB)
    11          :C
    12          :       WRITE(6,100)NW,STSH,ISTN,ELG,IST,LDB,IDATE,GWHR,XNRM
    13          :       GO TO 10
    14          :  50   STOP
    15          :C
    16          :  100  FORMAT(1X,I2,1X,A6,1X,I2,1X,A6,1X,I2,1X,I10,1X,A6,1X,E14.7,
    17          :      11X,F10.2)
    18          :       END

$BRKPT PRINT$
```

APPENDIX 2

ALGORITHMS USED

1. To Integrate Channel Powers:

$$CPI(I,J) = \frac{CP(I,J) \times \Delta GWH \times 3{,}600}{1.744 \times \frac{PEP}{100}}$$

where CP(I,J) is SORO channel power after a flux state, kW(th)

ΔGWH is change in reactor energy clock after the next BURN step, GWH(f)

PEP is the percent full power rating of the flux state

1.744 is 100% total Fission power of the reactor, GW(f)

2. To convert Integrated Channel Power to Fast Neutron Fluence

$$FNF(I,J) = \frac{CPI(I,J) \times k}{NK \times H} \qquad \frac{N}{cm^2} \cdot \frac{kW(th)}{kW(F)}$$

where NK = # of bundles (12)
H = bundle length (49.5 cm)
$k = 2.18 \times 10^{12}\ N/cm^2\ (kw/cm)^{-1}$

Note: The fluence maps as generated by the CNS programs use the above equation and are not fully converted for the difference between thermal and fission power units. These maps are low by 5.5% (1/.94725).

3. To convert Fast Neutron Flux to Channel GWH

$$CGWH(I,J) = \frac{FNF(I,J) \times NK \times H}{K \times 10^6 \times 3{,}600 \times .94725}$$

Note: (1) Channel GWH, when summed over all I,J channels should equal the SORO GWH and provides a useful check on the accuracy of the integration. The checks built into the current program are not corrected for fission power.

(2) All channel growth rates in mm/GWH quoted in this report are calculated using this equation. Regression analyses are performed using channel GWH as a function of elongation and the derived slope would be an average mm/Channel GWH.

4. To derive the Relative Channel Power (GW(f))

$$RCP(I,J) = \frac{1.744 \times CPI(I,J)}{\sum_{I,J} CPI(I,J)}$$

Note: Channel power cannot be derived from the fluence maps: this equation assumes that channel GWH is a function of channel power on any one map, and reactor operation at 100% full fission power.

5. To convert channel GWH to 7,000 EFPH

$$7KEFPH(I,J) = \frac{CGWH(I,J)}{RCP(I,J) \times 7{,}000}$$

6. To convert a growth rate from mm/GWH to mm/7000 EFPH

$$\frac{mm}{GWH} \times RCP(I,J) \times 7000$$

7. To determine the average growth rate in a zone

$$\sum_{I,J} RATE(I,J) \times \sum_{I,J} RCP(I,J) \times 7000$$